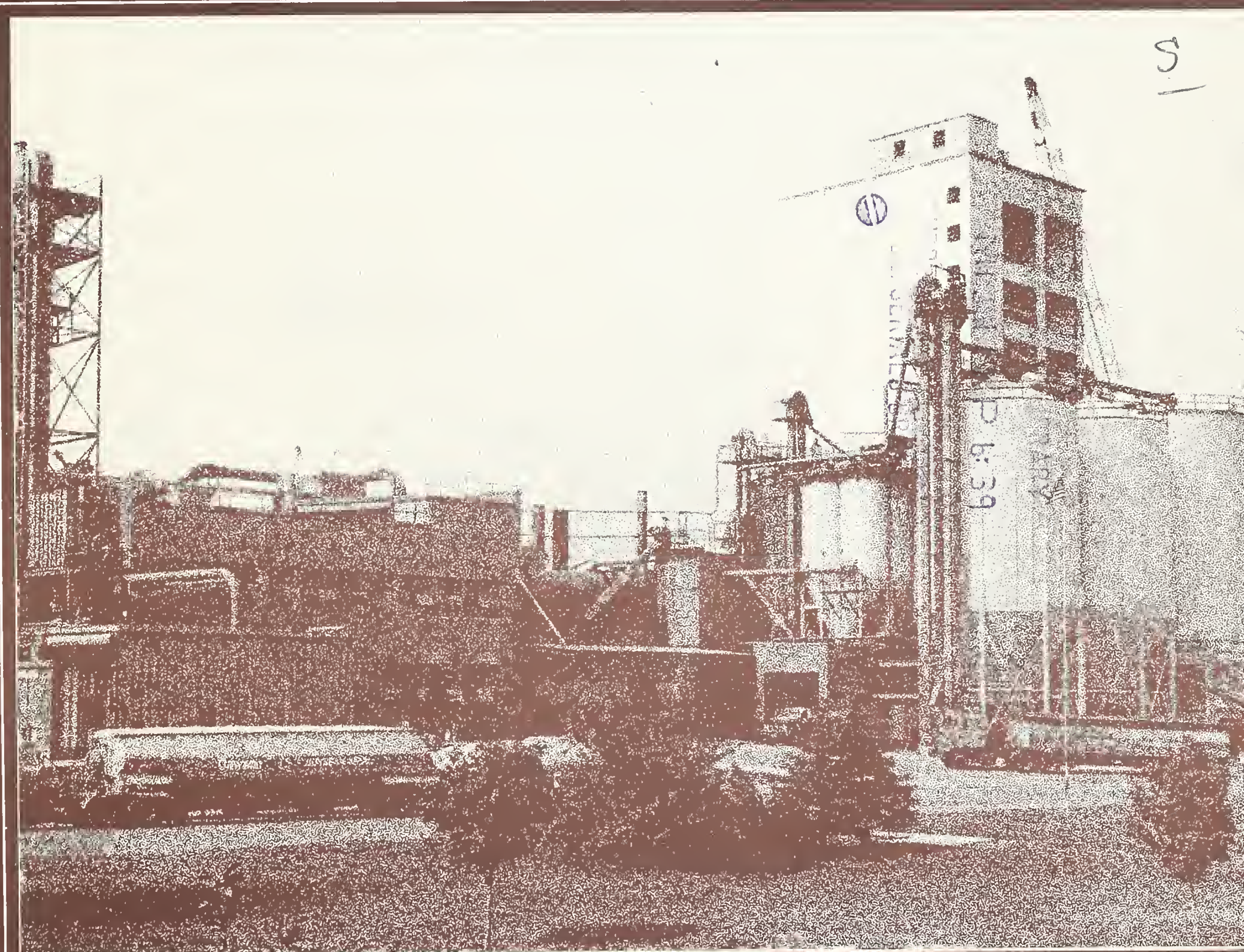
e Soy Protein

Operational Aspects of Producing and Marketing



Farmer Cooperative Service
U.S. Department of Agriculture

FCS Research Report 33

The Dawson Mills soybean processing complex, located at Dawson, Minn., is highlighted above and in the cover photograph. Part of the extractor plant and edible soy plant are shown on the cover, while offices and storage facilities are pictured above.

PREFACE

Faced with the question of whether or not to start producing and marketing edible soy protein, several soybean processing cooperatives turned to Farmer Cooperative Service (FCS) for help. Essentially, they each wanted FCS to marshal and analyze the facts. Because the requests were similar, FCS concluded that the prudent approach would be to gather the available facts and prepare a report that would be made available to anyone who wanted it.

Contacts with Government agencies bore fruit. Because they are public institutions, they were willing to share information they have developed. The principal and most valuable source of information was the Northern Regional Research Laboratory (NRRL) at Peoria, Ill. NRRL is a part of the Agricultural Research Service (ARS), U.S. Department of Agriculture (USDA). The Economic Research Service (ERS) and Food and Nutrition Service (FNS), USDA, also provided information. Information on current good manufacturing practices came from the Food and Drug Administration (FDA), Department of Health, Education, and Welfare (HEW).

Some technical, operational, and economic information was held by private companies. Because they had invested substantial resources to develop these kinds of information and to capture a share of the market for themselves, they were understandably reluctant to release such information for publication.

To assure proper credit for the individuals contributing to this report, the author of a particular section is identified in that section. Those sections that do not have a specific author identified were prepared by Bert D. Miner, FCS.

The contents are grouped under seven major headings. After a brief introduction, the different kinds of soy products, their uses and production and outlets are described. Processes, equipment, capital and processing costs are then treated. Because soy products are being prepared for human consumption, a section is included on current good manufacturing practice. Market growth and market potential are examined next. An appendix section of companies producing and distributing soy products is included for reference.

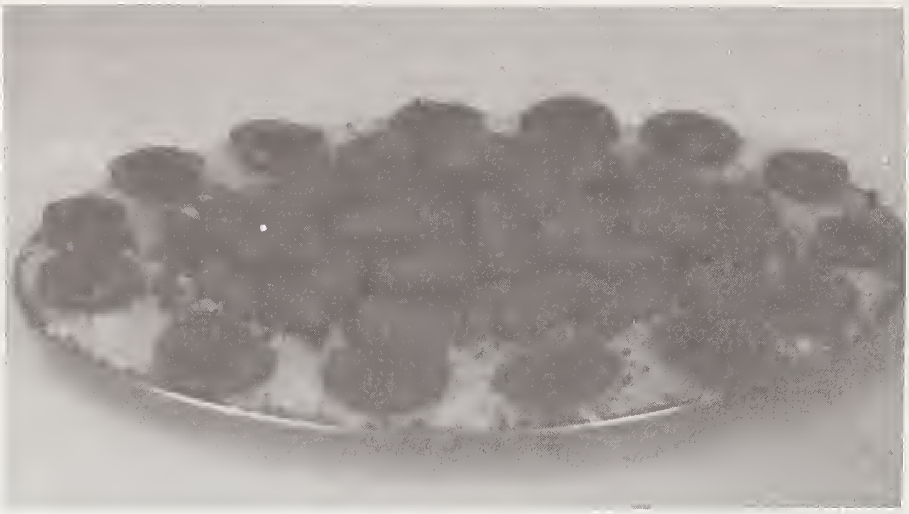
The use of firm and equipment names is for identification only and not intended as an endorsement by the U.S. Department of Agriculture.

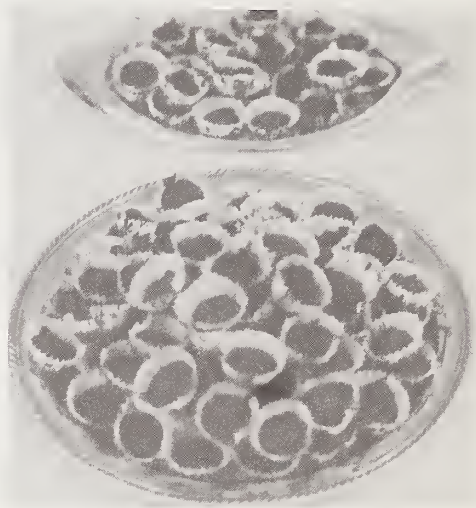
Citations in parentheses in sections refer to literature cited lists at the end of the section.

CONTENTS

HIGHLIGHTS

- The three principal classifications of edible soybean proteins are flours and grits, concentrates, and isolates. These are based upon percentage of protein content—40–50, 70, and 90–95. From these, textured protein products are made.
- Heat-treatment of defatted soybean flakes needs to be very carefully controlled because of its effect on protein color, flavor, and functional properties—fat and water absorption and solubility.
- Soy protein is added to other foods to provide functional properties and to supply dietary protein. These two important uses make soy proteins acceptable for use in a broad variety of foods.
- The fastest growing segment of the edible soy protein business has been textured items, mainly of the extruded flour type. It is also the most competitive.
- Economic processes and efficient equipment are presently available to produce edible soy protein.
- Assuring a high standard of sanitation in any plant producing edible soy protein is absolutely essential. Construction of a plant to produce edible soy protein must include provisions for effluent disposition in harmony with Environmental Protection Agency (EPA) standards.
- The relative cost of soy proteins, compared with that of animal proteins, indicates that soy proteins will continue to expand present markets and penetrate new markets. Development of additional desired qualities in soy proteins will speed their market expansion and penetration.
- The largest and fastest growing market for soy protein is expected to be in meat extenders and meat analogs.
- Government regulations are expected to be modified to favor additional uses and quantities of soy protein in foods.
- Institutions are the major market for soy protein products and are expected to continue to be for some time. The School Lunch Program is by far the largest institutional market.
- Large quantities of soy protein are expected to be used in foreign feeding programs, particularly those conducted under P.L. 480.





Display of edible soy protein products

EDIBLE SOY PROTEIN:

Operational Aspects of Producing and Marketing

Bert D. Miner
Farmer Cooperative Service

INTRODUCTION

During the past 30 years, the soybean has sprung from relative obscurity to stardom. The principal role that has brought about such world acclaim is the meal that has provided a major source of protein supplement for animal feed. It has been more recent that soybean oil has begun to demonstrate an important independent role. Edible soy protein is still waiting for its big chance.

We hear and read much about the awesome need for protein to feed the multitude of hungry people around the world. We also hear and read much about the alleged inefficiency of producing animal protein as opposed to producing vegetable protein, particularly soy protein. Yet despite the obvious human need, we are still confronted by the complex economics of production, distribution, and consumption when we make business decisions. In other words, need is not economic demand. Demand is need or desire coupled with purchasing power. Economic enterprises produce to satisfy demand rather than need. The broad economic aspects of this complex problem are far beyond the scope of this report. This report is limited to setting forth some of the economic and operational aspects of producing and marketing edible soy protein. We expect that the contents will provide a substantive basis upon which to make a decision of whether or not to initiate production of edible soy protein.

Food scientist, Kris Olson, prepares taste samples in Dawson Mills test kitchen.

KINDS OF SOY PRODUCTS

W. J. Wolf
Northern Regional Research Laboratory

Edible soybean proteins are classified according to protein content:

Products	*Protein content* *Percent*
Flours and grits	40–50
Concentrates	70
Isolates	90–95

Figure 1 shows the proximate compositions and yields of these protein forms in relation to soybeans.

Initial applications of soybean proteins in foods were at low levels to provide desirable functional properties such as emulsification, water absorption, and texture. As animal proteins have risen in price, soy proteins have become more valuable as dietary protein sources, because they provide functional properties. The best example of food products utilizing soybean proteins for nutritional purposes are the textured soybean proteins now used as meat extenders and meat analogs. These are made by further processing of flours and grits, concentrates, and isolates. Each of these three basic protein forms will be described as well as their conversion into textured products.

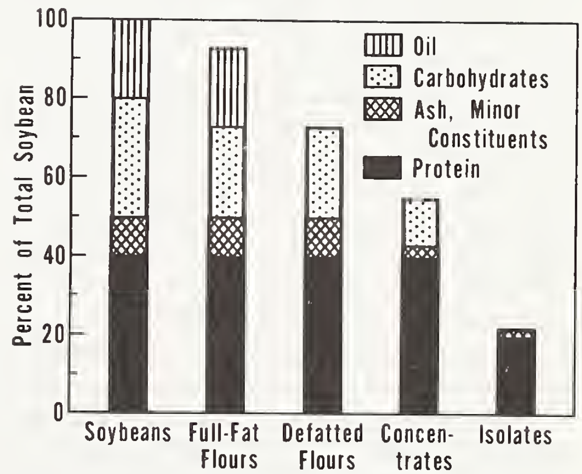


Figure 1.—Proximate compositions (dry basis) and yields of the major protein forms obtained from soybeans.

Effect of Moist Heat on Soybean Proteins

Before describing the various protein forms in more detail, it is necessary to understand the effects of moist heat on the properties of

the proteins. Moist heat treatment (commonly called toasting) is used in the production of a number of soybean products when there is need to inactivate enzymes, such as lipoxygenase, which can reduce storage stability or to destroy antinutritional factors, such as trypsin inhibitor.

Proteins in soybean flakes and flours that have been processed with little or no moist heat treatment are easily extracted with water. If the flakes are steamed, however, the proteins are denatured and are no longer soluble in water. Denaturation is a complex change that occurs in many proteins when they are treated with moist heat or with aqueous alcohol. One of the most common changes noted when proteins are denatured is a loss of solubility in aqueous solutions (for example, coagulation of egg white in a boiled egg). Figure 2 shows that protein solubility of soybean flakes (measured as Kjeldahl nitrogen in a water extract of flakes) drops very rapidly from its initial high value to 20 to 25 percent after steaming for only 10 minutes at atmospheric pressure. The presence or absence of oil in the flakes has no significant effect on the rate of protein insolubilization. Three factors—time, temperature, and moisture content—are critical in controlling rate of soybean protein denaturation (Becker, 1971). Because denaturation causes insolubilization of soybean proteins, solubility measurements are used to determine the extent of heat treatment given to flakes, flours, and grits.

Two empirical methods are commonly employed to measure the degree of protein denaturation in soybean flours and grits: nitrogen solubility index (NSI) and protein dispersibility index (PDI). In both procedures, the sample is stirred with water under specified conditions and centrifuged; the resulting supernatant is then analyzed for Kjeldahl nitrogen (American Oil Chemists' Society, 1973). For some other commodities, such as cottonseed flour, conditions for protein solubility determination are further modified by use of alkali instead of water. NSI and PDI values are the percent of total nitrogen in the sample that is soluble, although PDI is expressed as a percent of protein (N X 6.25).

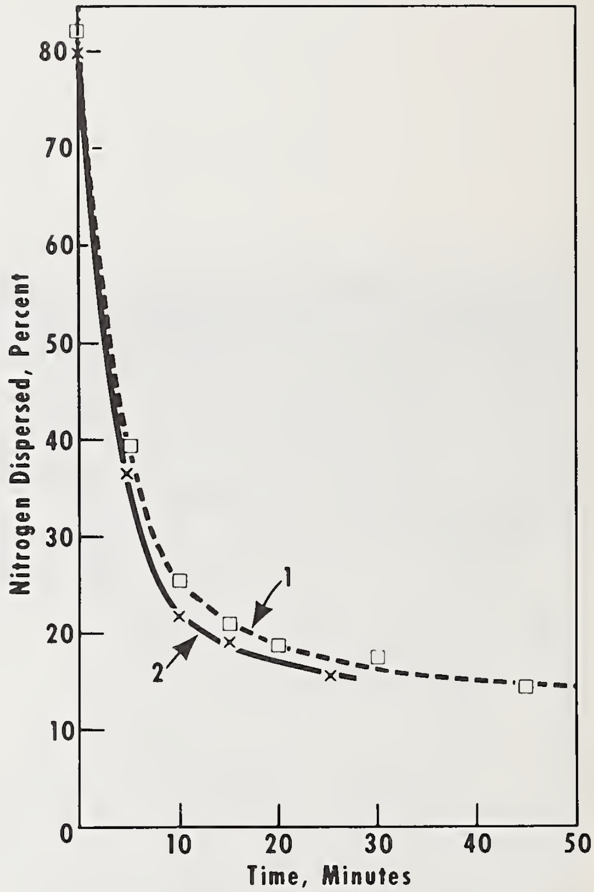


Figure 2.—Effect of steaming time at atmospheric pressure on water dispersibility of nitrogenous constituents of (1) defatted flakes and (2) full-fat flakes. From Belter and Smith (1952).

The two methods do not give identical values for a given sample because their extraction conditions differ. The NSI procedure uses slow stirring during the extraction step, whereas the PDI method employs fast stirring with a modified blender that chops the sample during extraction. A plot of PDI versus NSI (fig. 3) shows that PDI values are higher than NSI for a given series of samples. Figure

3 shows that after NSI and PDI reach minimal values, they will no longer indicate the extent of heat treatment; NSI and PDI values are not valid indicators of overcooking.

Another test frequently used to assess degree of heat treatment given to soy flours and grits is urease activity (American Oil Chemists' Society, 1970). The soybean sample is incubated with a buffered solution of urea. If the enzyme urease is active, it hydrolyzes urea to release ammonia, which in turn causes an increase in pH of the incubation mixture. Increase in pH is used as a measure of urease activity, but the test is applicable only to samples that have had moderate to full cooking. The relationship between pH increase and urease activity is not linear over the entire range from raw to fully cooked.

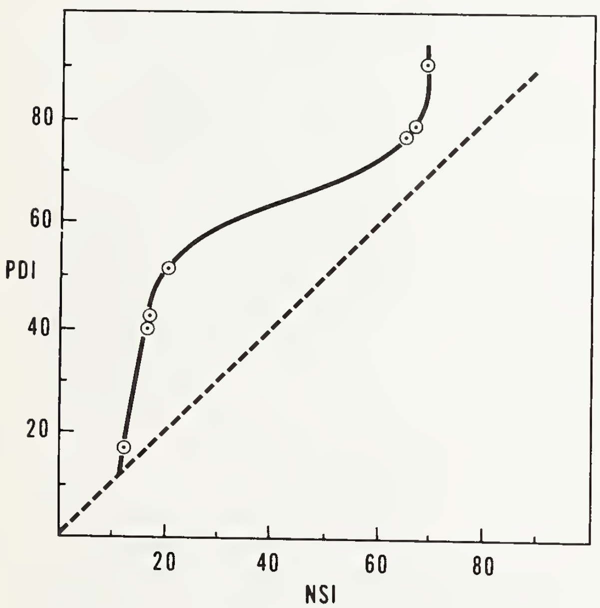


Figure 3.—Plot of nitrogen solubility index versus protein dispersibility index for a series of heated samples. The dashed line is the curve expected if the two values are identical. Adapted from Horan (1974A).

Raw soybeans contain antinutritional factors, such as trypsin inhibitors, that cause poor growth when they are fed to animals (Smith and Circle, 1972). The antinutritional factors are readily inactivated by moist heat treatment; consequently, all defatted meal used for feeds is thoroughly cooked or toasted. For food uses, however, it is often unnecessary or undesirable to completely cook soybean protein products before incorporating them into food items. Additional processing by the food manufacturer is relied upon to adequately heat-treat the proteins. In addition to improving nutritional value and decreasing protein solubility, heat treatment also affects flavor, color, and functional properties such as fat and water absorption.

Flours and Grits

Edible soy flours and grits are made from dehulled beans and are classified according to particle size:

Product	*Mesh size**
Grits:	
Coarse	10–20
Medium	20–50
Fine	50–80
Flours	100 or finer

* U.S. standard screen

Grits are prepared by coarse grinding and screening, compared with flours that are ground until 97 percent of the material passes through a 100-mesh screen. Many soy flours are ground to 200-mesh size and specialty flours of 300-mesh size are also available. The term flour as applied to soy refers only to particle size; no similarity to wheat flour is intended.

In addition to varying in particle size, available flours and grits also differ in fat content. Standards for soy flours used in the trade are given in table 1. Typical analyses for these products plus lecithinated grits and flours are shown in table 2.

Full-Fat Products.—In commercial preparation of full-fat flours and grits, the beans are cleaned, cooked, dried, cracked, dehulled, ground, and screened (Pringle, 1974). Altern-

Table 1—Soy flour standards [1]

Constituent	Full-fat soy flour	Low-fat soy flour	Defatted soy flour
		Percent	
Protein (N X 6.25) [2]	40.0 min.	45.0 min.	50.0 min.
Protein (N X 5.7) [2]	36.5 min.	41.0 min.	45.0 min.
Fat (ether extract) [2]	18.0 min.	4.5 min.—9.0 max.	2.0 max.
Fiber [2]	3.0 max.	3.3 max.	3.5 max.
Moisture	8.0 max.	8.0 max.	8.0 max.
Ash [2]	5.5 max.	6.5 max.	6.5 max.

[1] From Soybean Digest Blue Book Issue (1974). 97 percent will pass through a No. 100 U.S. standard screen for each of the above.
[2] Moisture-free basis.

Table 2—Proximate analyses of flours and grits [1]

Constituent	Flour or grit			
	Full fat	Low fat	Defatted	Lecithinated
		Percent		
Moisture	5.0	5.5	5.0	5.5
Protein (N X 6.25)	41.5	46.0	53.0	45.2
Fat	21.0	6.5	0.9	16.4
Crude fiber	2.1	3.0	2.9	2.4
Ash	5.2	5.5	6.0	5.3

[1] As-is basis. Analyses are not product standards but are typical for products (Meyer, 1970).

tively, the beans may be cracked and dehulled before heating (Horan, 1974A). Full-fat flours are the least refined commercial soybean protein products, because only the hulls are removed. Hulls consist mainly of indigestible carbohydrates cellulose and hemicelluloses. Cooking is used to inactivate enzymes, such as lipoxygenase that, if permitted to remain active, are believed to catalyze oxidation of linoleic and linolenic acids in the oil and in turn lead to development of off-flavors (Mustakas and others, 1969; Nelson and others, 1971). Commercial full-fat flour has a PDI value of 35 to 45, which reflects the initial cooking step. A pilot process for preparing full-fat flour by extrusion cooking has recently been developed (Mustakas and others, 1970). This process is being used in a number of installations overseas, and is described in detail in the section, Soy Processes, Equipment, Capital, and Processing Costs.

Defatted Products.—Defatted flours and grits are made by the following sequence of steps: cleaning, cracking, dehulling, conditioning, flaking, extracting, desolventizing, grinding, and screening. The oil as well as the seedcoat is removed during this processing. The oil is extracted with hexane, and as a result, defatted grits and flours contain a minimum of 50 percent protein, but typically will analyze higher (table 2). Defatted grits and flours are the major soybean protein form produced at present and are also the starting materials for further processing into protein concentrates and isolates.

To provide food ingredients with a wide variety of properties, defatted flours and grits are available with a range of moist heat treatments. Smith and Circle (1972) give the following classification of flours and grits according to the extent of heat treatment and NSI values:

Amount of heat	*NSI*
Minimum	85–90
Light	40–60
Moderate	20–40
Fully toasted	10–20

The critical step in preparation of defatted flours and grits with varying heat treatments is desolventizing. Flakes coming from the extractor contain about 30 percent hexane; in conventional processing for feeds, hexane is removed and recovered in a desolventizer-toaster that uses steam to evaporate the hexane for recovery and to cook or toast the flakes. For edible purposes, less than complete cooking is often desired; hence, other methods are employed for desolventizing (table 3).

The Schneckens system is the oldest method now used and provides flours and grits with PDI values that lie between a raw and a fully cooked product. If an undenatured flake is desired for conversion into one form (isoelectric washed) of protein concentrate or protein isolate, then either the flash desolventizer-deodorizer or vapor desolventizer-deodorizer can be used. If steam sparge used in the deodorization step of the vapor desolventizer-deodorizer is done under vacuum, one obtains a flake with a high PDI. But if the deodorization is carried out under 1 to 2 atmospheres

Table 3—Processes used to desolventize soybean flakes for edible products

Process	Method of hexane vaporization	PDI range of flakes [1]
Schneckens	Steam jacketed conveyor with steam sparge [2]	40-50
Flash desolventizer-deodorizer	Superheated hexane followed by inert purge gas	70-90 [3]
Vapor desolventizer-deodorizer	Superheated hexane followed by steam sparge under vacuum or pressure	10-90

[1] Becker, 1971. PDI = protein dispersibility index.
[2] Newer versions of this system use hollow-screw conveyers with heat transfer agents circulating through them to increase heat transfer efficiency.
[3] When flakes with lower PDI values are desired, the flash desolventizer is followed by a meal stripping and cooking operation (Milligan and Suriano, 1974).

of pressure, the steam condenses and the PDI value goes down. Flakes spanning the entire range of PDI values can therefore be prepared by controlling conditions during deodorization.

Defatted flours and grits can also serve as the starting material for low-fat and lecithinated products. These items are usually made by adding back the desired level of oil or lecithin to defatted materials; small quantities of low-fat flours and grits are made by expeller processing to reduce the oil content of dehulled beans to 6 percent.

Protein Concentrates

Concentrates are made from defatted flours or grits by removing soluble sugars (sucrose, raffinose, and stachyose), along with some ash and minor constituents, as shown in figure 4. Sugars make up about one-half of total carbohydrates of defatted flours; the other half consists of indigestible polysaccharides that make up the cell walls in soybeans. Sugars are removed by extracting with: (1) aqueous alcohol (Mustakas and others, 1962); (2) dilute aqueous acid (Sair, 1959); or (3) water, after first insolubilizing the proteins by moist heating (McAnelly, 1964). All these processes are patented, although the alcohol extraction process patent is assigned to the U.S. Government (Mustakas and Griffin, 1966) and is available for licensing on a nonexclusive, royalty-free basis. In all three extraction processes, proteins and polysaccharides remain insoluble and are recovered in the final product.

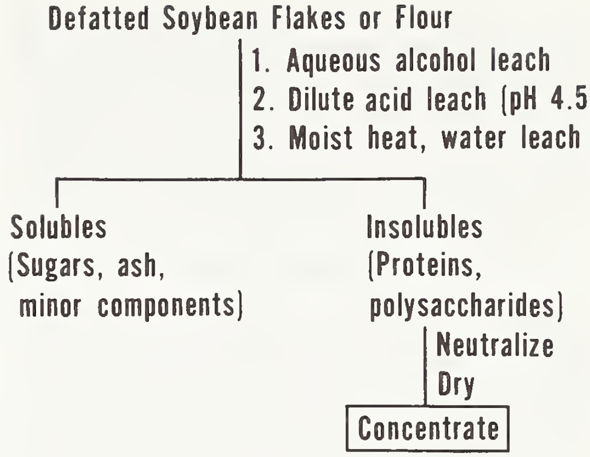


Figure 4.—Processes for preparing soybean protein concentrates. Extraction of sugars is made by one of three alternate methods as described in the text.

Table 4 gives proximate analyses of three commercially available protein concentrates. Chemical compositions are quite similar for the three concentrate types, but a major dif-

Table 4—Proximate analyses of soy protein concentrates [1]

Property or constituent	Manufacturing process		
	Alcohol leach	Acid leach	Moist-heat, water-leach
NSI [2]	5	69	3
pH of 1:10 water dispersion	6.9	6.6	6.9
		Percent	
Protein (N X 6.25)	66	67	70
Moisture	6.7	5.2	3.1
Fat (petroleum ether extractable)	0.3	0.3	1.2
Crude fiber	3.5	3.4	4.4
Ash	5.6	4.8	3.7

[1] As-is basis. From Meyer (1970).
[2] NSI = nitrogen solubility index.

ference exists in the physical properties. The concentrates made by the alcohol leach and moist-heat, water-leach processes have very low NSI values. In the first process, aqueous alcohol and heat cause protein denaturation, whereas in the second process, steam treatment insolubilizes the proteins.

Protein Isolates

Isolates are the most refined form of soybean proteins available commercially. By definition, they must contain a minimum of 90 percent protein (N X 6.25) but often analyze 95 percent or better. Like concentrates, isolates are made from defatted flakes or flours, but the starting material must have a high NSI or PDI value to ensure economical yields of protein. The isolation process is summarized in figure 5. Defatted flakes are extracted with water plus sufficient alkali to adjust the pH to 7 to 9. Spent flakes, which contain the water-insoluble polysaccharides plus some residual protein, are then separated by filtration or centrifugation. The clarified extract, containing most of the proteins plus sugars, is acidified to about pH 4.5. This step adjusts the proteins to their isoelectric point and causes them to coagulate so that they can be separated by centrifugation or filtration. The supernatant or filtrate (also referred to as soybean whey) contains sugars, ash, and minor constituents. Next, the protein curd is washed,

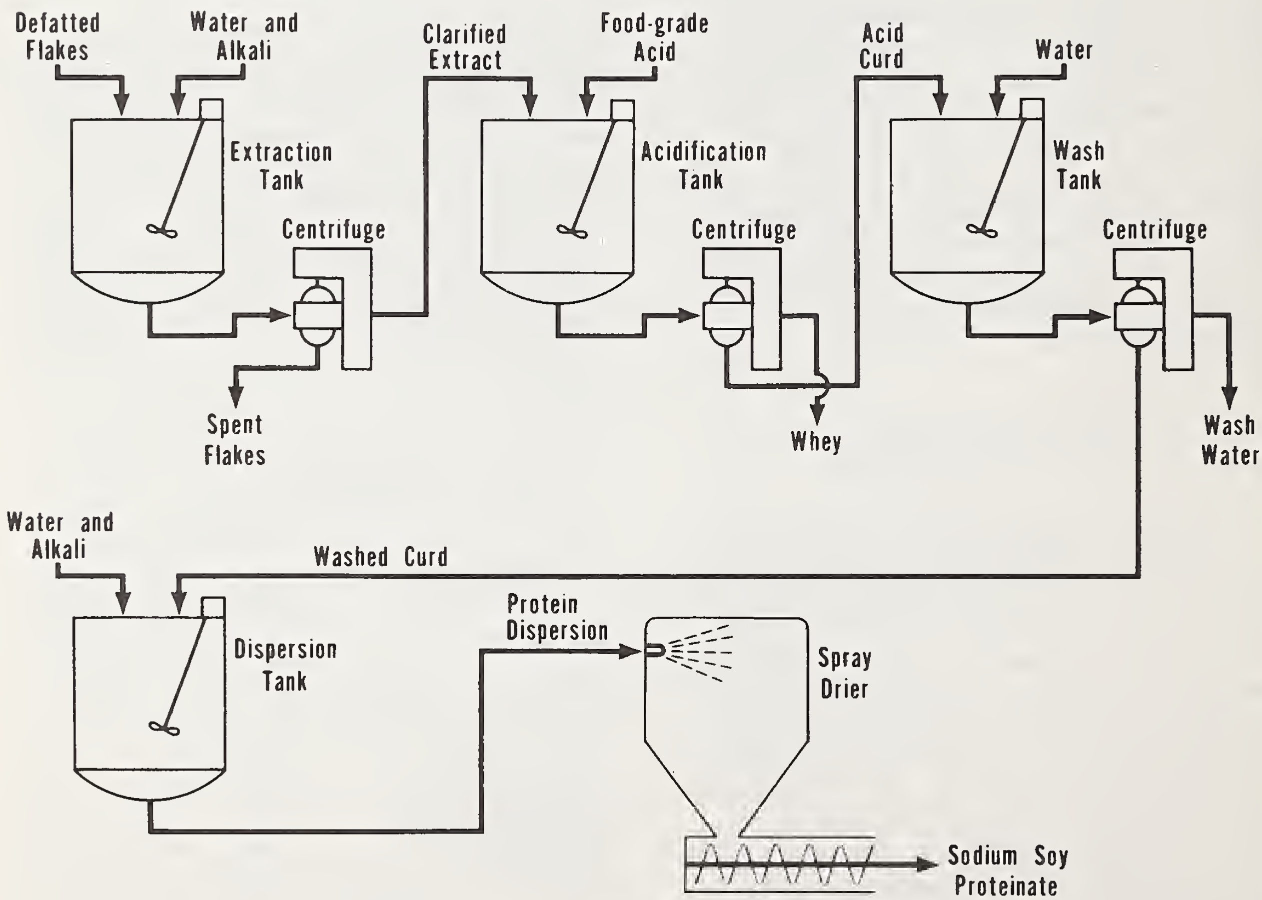


Figure 5.—Process for production of soybean protein isolates.

slurried in water, and spray-dried to give the isoelectric protein. More commonly, however, the protein is neutralized with alkali and then spray-dried to yield the sodium proteinate form. Table 5 gives proximate analyses for four commercial samples of isolates. Samples A and B were neutralized before drying, whereas samples C and D were left in the acidified condition. The proteinate samples have high NSI values, whereas the isoelectric samples are insoluble in water.

Table 5—Proximate analyses for four commercial soy-protein isolates[1]

Property or constituent	A	B	C	D
NSI[2]	85	95	---	---
pH of 1:10 water dispersion	7.1	6.8	5.2	5.5
		Percent		
Protein (N X 6.25)	92.8	92.2	92.9	94.7
Moisture	4.7	6.4	7.6	3.7
Crude fiber	0.2	0.1	0.1	0.2
Ash	3.8	3.5	2.0	2.7

[1] As-is basis. From Meyer (1970).
[2] NSI = nitrogen solubility index.

Small amounts of protein isolates (estimated to be less than a million pounds in 1967; Eley, 1968) are treated with the proteolytic enzyme pepsin to partially hydrolyze the protein for use as a whipping agent in the confectionery and bakery trades. These products are often referred to as modified or enzyme-modified isolates.

Textured Soybean Protein Products

Further processing of the basic forms—flours and grits, concentrates, and isolates—is now practiced to give soybean proteins a texture that resembles specific types of meat; these items range from extenders to be used with ground meats to complete meat analogs. The textured protein products are of two general categories: (1) extruded soy flours and (2) spun protein isolates. However, this distinction is being blurred by new products. One consists of a mixture of soy flour, protein concentrate, and protein isolate, although soy flour is the major ingredient. Another product contains soy protein concentrate, spun soy isolate, and isolated soy protein in order of decreasing proportions. U.S. patent literature on textured products for 1960 to 1972 was summarized by Gutcho (1973), and a detailed review of meat analogs appeared recently (Horan, 1974B).

Extruded Soy Flours.—Extruded flours are made by mixing defatted soy flour with water plus flavors, colors, and supplementary nutrients, if desired, and then passing the mixture through a cooker-extruder. Elevated pressure and temperature in the extruder convert the wet flour into a plastic mass that is extruded through a die. The pressure and temperature drop that occur on extrusion cause expansion and a fibrous structure. The expanded product is then dried to about 8 percent moisture. The extrusion process gives the soy flour a chewy texture when it is hydrated. This is the major type of textured product currently available, and about a dozen companies now make these materials (see Table 8, Production Estimates and Market Outlets). The process is patented (Atkinson, 1970) and licensing is required.

Another process for texturizing soy flour was described more recently by Strommer (1973). Soy flour is introduced into a multichambered rotary valve, and as the valve turns, the soy flour is subjected to high-pressure steam and ejected through a nozzle into a zone of low pressure. The sudden pressure drop causes a texturizing and flashes off volatile compounds that contribute undesirable flavors in soy flour. In contrast to the extrusion process, this treatment involves no mechanical working of the soy flour except for the instant during ejection through the outlet nozzle. In the examples cited by Strommer, blends of soy flour, protein cencentrates, and protein isolates were texturized.

Composition of textured soy flours is essentially the same as that of defatted flours and grits—that is, about 50 percent protein. Flavors, colors, and supplements of vitamins and minerals, when added, do not change overall composition significantly. Advantages of textured soy flours over spun protein isolates include: (1) ease of manufacture; (2) low cost; and (3) long storage life. The bacterial

count for these products is low and under normal storage conditions they can keep for at least a year. They are, however, limited in their applications because they do not have the high degree of meat-like texture characteristic of the spun fiber products.

Spun Protein Isolates.—The basic process for spinning soy protein isolates into meat-like fibers was first described in a patent issued to Boyer (1954). The basic patent has expired but companies now engaged in this business hold patents on improved versions of the original invention and on methods for converting the fibers into meat analogs (Hartman, 1967; Tombs, 1972; Westeen and Kuramoto, 1964).

Spinning is a complex operation involving a highly sophisticated technology and requires large capital investments (Thulin and Kuramoto, 1967). Protein isolate is dispersed in alkaline solution, which is then filtered and forced through a spinnerette (a metal plate, usually platinum, with up to 15,000 holes about 0.003 inch in diameter) into an acid-salt bath that coagulates the streamlets of protein solution as they emerge to form fibers. Bundles of fibers or "tows" are then drawn from the coagulating bath with power-driven rolls to stretch and toughen them. The stretched fibers are then passed through a washing bath to remove the acid-salt coagulant, followed by immersion in a vat containing a binder (such as egg albumin). After impregnating the tow with binder, it is heated to set the binder and to cement the fibers together. Next, fat, flavors, colors, and nutrients—such as vitamins—can be added. After appropriate shaping, cutting, and drying, a variety of analogs of ham, beef, chicken, and seafood can be prepared.

Composition of the final products made from spun fibers will vary, but a typical composition is given in table 6. Some analogs such as fried bacon-like bits are low enough in moisture to keep at room temperature, but many contain 50 percent moisture or higher and are sold frozen in a ready-to-eat form. Storage of these products is therefore more expensive than that for textured flours. The spun fiber products, however, have the advantages of being more meat-like in texture and providing flexibility in composition of the end product. Because of the complex processing required, including the use of protein isolate, spun fiber products are more expensive than textured flours.

Table 6—Composition of spun protein isolate products [1]

Component	Percent
Spun fiber	40
Protein binder	10
Fat	20
Flavors, colors, and supplemental nutrients	30

[1] Dry basis. From Thulin and Kuramoto (1967).

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PRODUCT USES

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The various soy protein products now available are added to a large number of food items for two reasons: (1) to provide functional properties and (2) to supply dietary protein.

Functional Properties

A functional property is one that imparts desirable changes to a food during processing or in the finished product. Examples of functional properties are water absorption, viscosity, emulsification, fat absorption, and texture. In many applications, the functional effects are obtained with only a few percent of soy protein; hence, the contribution to dietary protein may be minor.

A given functional property does not always ensure use of soy protein in certain foods. For example, when isolates are washed with aqueous alcohols, their solutions can be whipped to form very stable foams, but these foams do not have the additional functional property of heat-setting that is characteristic of egg white proteins. Consequently, alcohol-washed soy proteins are not suitable as replacements for egg whites in angel food cakes (Eldridge and others, 1963).

Often it is necessary to make adjustments in the formulation before soy proteins can be added to a given food. Use of soy flour in bread frequently leads to a decrease in loaf volume but this can be overcome by adding oxidizing agents such as potassium bromate or dough conditioners such as sodium stearoyl lactylate (Tsen and Hoover, 1973).

Tests for evaluating the functional properties of soy proteins are largely empirical and hence not very reliable for predicting the performance of the proteins when they are added to a given food. The only reliable way to evaluate effectiveness of soy proteins for this purpose is to incorporate them into the formulation and prepare the finished food product. For more detailed discussions of the functional properties of soy proteins, see reviews by Johnson (1970), Wolf (1970), and Smith and Circle (1972).

Dietary Protein

Use of soy proteins at high levels as a dietary source of protein is a recent development. The best examples of this application are the textured soy proteins that serve as extenders or complete replacements for meat. Functional properties, however, are also important in these uses. In fact, success of soy proteins as meat extenders and meat analogs depends largely on their ability to assume a meat-like texture and to retain it during cooking.

The characteristic beany and bitter flavors of raw soybeans are difficult to remove completely by processing. Consequently, flavor has been a factor limiting the use of soy protein in some foods, especially those with bland flavors. Concentrates and isolates were developed to overcome the flavor of flours and grits, but the problem has not been completely solved for some potential applications such as dairy-type foods. Flavor may therefore be a barrier to extensive use of soy proteins for dietary purposes; that is, at levels high enough to be a significant source of protein in the diet.

Table 7 is a listing of food uses for the different soy protein forms currently marketed.

Flours and Grits

A major application of flours and grits is in bakery products. Rapid rises in the price of nonfat dry milk solids in recent years have nearly priced this commodity out of the market as a normal bread ingredient (Cotton, 1974). During July-September 1974, the wholesale price of nonfat dry milk was 57 cents per pound. As a result, soy flour blended with dry whey solids (byproducts of cheese manufacture) is used extensively at a level of

Table 7—Food uses of soy proteins

Protein form	Uses
Flours and grits	Bakery products:
	Bread, rolls, and buns
	Doughnuts
	Sweet goods
	Cakes and cake mixes
	Pancake and waffle mixes
	Specialty crackers and cookies
	Meat products:
	Sausages
	Luncheon loaves
	Patties
	Canned meats in sauces
	Breakfast cereals
	Infant and junior foods
	Confectionery items
	Dietary foods
Textured flours	Ground meat extenders
	Meat analogs (bacon-like bits, etc.)
Concentrates	Bakery products:
	Bread, biscuits, and buns
	Cakes and cake mixes
	Meat products:
	Sausages
	Luncheon loaves
	Poultry rolls
	Patties
	Meat loaves
	Canned meats in sauces
	Breakfast cereals
	Infant foods
	Dietary foods
Isolates	Meat products:
	Sausages
	Luncheon loaves
	Poultry rolls
	Dairy-type foods:
	Whipped toppings
	Coffee whiteners
	Frozen desserts
	Beverage powders
	Infant foods
	Dietary foods
Spun isolates	Meat analogs:
	Bacon-like bits
	Simulated sausages
	Simulated ham chunks
	Simulated chicken chunks
	Simulated bacon slices
	Meat extenders

1.5 to 2.0 pounds of soy flour per 100 pounds of wheat flour. The added soy flour-whey blend increases the protein content of the bread and improves the amino acid balance of the wheat proteins by supplying lysine. In other bakery applications, soy flours often are employed primarily for their functional properties. For example, addition of soy flour to doughnuts helps reduce absorption of fat during frying; in pancake and waffle mixes it contributes to desirable browning in the fried products. Soy proteins have good water-holding capacities; hence, help maintain freshness of bread. Some bakers add about 1 percent of a raw soy flour preparation (soy flour plus corn flour) to white breads for bleaching purposes. Raw soy flour contain the enzyme lipoxygenase which catalyzes reactions with polyunsaturated fatty acids that in turn cause bleaching of the yellow pigments in wheat. It is also claimed that bread flavor is improved as a result of action by the enzyme.

Soy flours are added to processed meats largely for functional purposes—binding, emulsion stabilization, and fat absorption (Rakosky, 1974). Textured soy flours are utilized extensively as extenders for ground beef both in retail markets (Wolford, 1974) and for institutional feeding such as school lunches, hospitals, and nursing homes. Smaller amounts of textured flours serve as replacements for meat—pizza toppings, simulated fried bacon bits, and related items.

Soy flour is also blended with cereals such as oats for infant and adult breakfast cereals. Some canned infant foods and infant cookies contain soy flour. Dietetic cookies and candy likewise have soy flour added to them.

Protein Concentrates

Protein concentrates find some of the same uses as flours. A major outlet for concentrates is in processed meats—sausages, meat balls, meat loaves, salisbury steak, and poultry rolls—for functional characteristics such as moisture absorption and fat-binding. Concentrates are blander and higher in portein content than flours. Certain ready-to-eat breakfast cereals and infant foods likewise contain protein concentrates.

Protein Isolates

Isolates are added to many of the same kinds of products as flours and concentrates—processed meats, infant foods, and dietary foods. Isolates are often used to replace the higher priced sodium caseinate in dairy-type items such as whipped toppings, liquid coffee whiteners, and frozen desserts. Instant cocoa mixes, instant breakfast preparations, and milk replacers are examples of beverage powder products containing protein isolates. Several milk-like formulas designed for infants who are allergic to cow's milk are based on soy protein isolates. Methionine is also added to these products to raise the nutritive value of soy protein to that of casein.

The ability to convert soy protein isolates into fibers has led to development of a variety of meat analogs. Until 1974, these products were sold primarily to the institutional trade—schools, nursing homes, and mental hospitals. Now, however, one company is selling frozen meat analogs in retail markets. In these products, spun fiber provides some of the chewiness that is characteristic of meats and can also supply a significant amount of dietary protein. A fried bacon bit analog containing spun isolate fibers has been available in many supermarkets for the past 5 years. Recently, a fresh, sliced bacon analog was introduced and another is currently in test markets.

The list of foods that contain soy proteins is growing but this fact is often obscured because the product labels generally do not call attention to individual components. Only on careful reading of the ingredient listing does it become apparent that the products contain soy proteins. For further information on food uses of soy proteins, the reader is referred to detailed reviews (Wolf, 1970; Wolf and Cowan, 1971; Smith and Circle, 1972) and the proceedings of the World Soy Protein Conference held in 1973 (American Soybean Association 1974).

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PRODUCTION ESTIMATES AND MARKET OUTLETS

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Soy flours and grits, the first edible soybean protein products produced commercially, have been available for about 40 years but they were not very successful initially because of poor flavor, dark color, and a high content of hulls. After World War II, however, the industry began to improve the flour and grits products and develop markets for them. The industry grew slowly and the more highly refined concentrates and isolates became available in 1959. By 1967, three processors produced more than 90 percent of the flours and grits, four firms prepared all the protein concentrates, and three companies manufactured all the isolates (Eley, 1968). Other companies have entered the business in recent years and now more than a dozen major firms manufacture and sell at least one form of soybean protein (table 8). Some new entries to the field are primarily in food manufacturing and also use soybean proteins as ingredients in their food items.

Production Estimates

Precise figures on the amounts of soybean proteins produced annually are not available because manufacturers consider this proprietary information. Two recent production estimates as well as recent selling prices are given in table 9. Figures for flours and grits include amounts used for pet foods and unknown amounts of these materials that are converted into other products (for examples, protein concentrates and textured soy flours) when further processing is carried out by other firms.

The most rapidly growing segment of the business has been the textured items that are mainly of the extruded soy flour type. This is also one of the most competitive areas because

Table 8—Principal U.S. producers of soybean protein products

Producer	Grits and flours			Concentrates	Isolates	Textured products	
	Defatted	Low fat*	Full fat			flours	isolates
Anderson Clayton Foods					+		
Archer-Daniels-Midland Co.	+	+	+	+**		+	
Cargill, Inc.	+	+***				+	
Carnation Co.					+		
Central Soya Co.	+	+	+	+	+	+	
FAR-MAR-CO.	+			+		+	
General Mills, Inc.						+	+
Grain Processing Corp.				+	+		
Griffith Laboratories				+		+	
Lauhoff Grain Co.	+					+	
Miles Laboratories, Inc.						+	+
Nabisco						+	
National Protein Corp.	+					+	
Ralston Purina Co.					+	+	+
A. E. Staley Mfg. Co.	+	+		+**	+****	+	
Swift & Co.	+			+		+	

* All producers of low-fat flours also offer lecithinated flours.
** Plant under construction.
*** Offers lecithinated but not low-fat flour.
**** Offers primarily pepsin modified isolates.
Note: Several additional companies supply specialty protein products from soybeans such as health foods, snacks, and confections. A listing of these companies can be found in the Soybean Digest Blue Book published annually by the American Soybean Association, Hudson, Iowa 50643.

many firms presently make and distribute textured products.

Table 9—Selling prices and production estimates for soybean proteins

Protein form	Price per pound[1]	Annual production 1972[2]	Annual production 1973[3]
	Cents	*—Million pounds—*	
Flours and grits	9-15	352-500	450-600
Concentrates	27-35	40-50	55
Isolates	58-64	35-40	50
Textured items:			
Extruded flours	19-20	35-40	110
Spun isolates	50 and up		

[1] Prices as of February 1975.
[2] Lockmiller (1973).
[3] Lockmiller (1975).

Market Outlets

Quantitative information on market outlets is also difficult to obtain but estimates have been made that indicate relative magnitudes of the various outlets involved. Table 10 lists estimates made by Eley (1968) for soy flours and grits for 1967. Eley believed that use of soy proteins was increasing at 5 to 7 percent a year at that time; hence his figures are likely to be well below the current use. For example, Cotton (1974) has given a more up-to-date and detailed breakdown of the annual soy flour use in baked goods:

Use	*Million lbs.*
Bread	50
Specialty items and crackers	14
Doughnut mixes and cakes	7
Total	71

The total soy flour now used in baked goods is more than 40 percent higher than the estimate made for 1967 (table 10).

Table 10—Market outlets for soybean products, 1967[1]

Outlet	Million pounds
Domestic:	
Baked goods	50
Meat products	30
Beverage products	10
Dry cereals and infant foods	6
Brewer's flakes	3
Pasta and macaroni	1
Miscellaneous	5–10
Subtotal	105–110
Exports	10
U.S. Government (overseas feeding)	100
Total	215–220

[1] Eley (1968).

Successful introduction of textured soybean proteins (mainly extruded flours or related products) into institutional food programs and at the retail level (ground beef and soy blends) plus addition of grits and flours to processed meats make meat products the largest single outlet for soybean proteins at present. In the institutional sector, the School Lunch Program is now the biggest consumer; about 25 million lunches are served daily. The School Lunch Program used about 9 million pounds of textured protein during the 1971-72 school year; in 1972-73, the amount is believed to have doubled (Bird, 1974). These products have been especially attractive to school officials faced with fixed budgets and rising prices for meat and also concerned with maintaining nutritional quality of meals distributed through their feeding programs (McCloud, 1974).

Outlets for concentrates are largely in processed foods—meats, breakfast cereals, and infant foods. The meat-processing industry is the largest of these outlets. Some concentrates with added vitamins and minerals are also used in the school lunch programs for extending meat dishes. Some companies mix concentrates with other soy protein forms in their textured products. For example, one firm blends concentrate with spun fiber and protein isolate to make a textured item intended for use as a meat extender.

The edible isolates are used almost exclusively by the food-processing industry. The major segments of the industry that incorporate isolates into their products are meat processing, meat analogs, dairy-type products, instant breakfast foods, and infant foods firms. The largest consumers of isolates are most likely the processors of meats and meat analogs. Predictions are that meat analogs will grow significantly in the future as discussed later (Market Growth). Isolates have been utilized in dairy-type products (whipped toppings, liquid coffee whiteners) and canned infant foods for several years. The use of isolates in instant breakfast items is recent and this application is probably the smallest at present but can be expected to

grow if isolates are successful in displacing sodium caseinate in these kinds of foods.

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SOY PROCESSES, EQUIPMENT, CAPITAL, AND PROCESSING COSTS

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Five basic commercial edible soybean products and their processes for manufacture were chosen for this analysis: (1) full-fat soy flour, (2) defatted soy flour, (3) soy protein concentrates, (4) soy protein isolates, and (5) textured soy protein produced from soy flour. Selection of products was based on the idea that soy processing cooperatives would manufacture basic and intermediate products that could be marketed as raw materials as well as used for finished foodstuffs. Substantial investments have been made by the soybean industry in these intermediates; textured soy protein is the most recently developed product.

Cost estimates for the various processes described were prepared, largely from data contained in patent literature and other published sources, and from data supplied by equipment manufacturers. Although the various products are made commercially, data on such production are limited and not readily available, and thus inadequate for preparing cost estimates. Therefore, these cost estimates must be considered preliminary figures only and are intended to serve merely as guidelines for studying the feasibility of producing soy protein materials. Costs are reported as of mid-1974.

The procedure for estimating costs follows generally accepted techniques. Installations for various processes are considered to be adjuncts to already-existing soybean oil extraction plants. Costs are restricted to and include only facilities directly associated with the process. Therefore, costs for such items as steam-generating facilities and equipment for receiving, cleaning, storing, and grinding whole soybeans do not form part of the estimates. However, charges for various utilities and, where applicable, charges for receiving, storing, and preparing beans are added to other cost items.

The following cost items are included in production costs: raw materials (defatted flour and chemicals), utilities, labor and supervision, maintenance and fixed charges. Selling and administrative expenses and profit are not included. Processing costs for full-fat flour do not include the cost of soybeans. Utility rates are as follows: steam, $1.00 per 1,000 pounds; water, $0.25 per 1,000 gallons; electricity, $0.025 per kilowatt-hour; gas, $1.00 per 1,000 cubic feet. Maintenance for equipment is calculated at 5 percent a year on the erected equipment cost and for land and building, 2 percent a year of their cost. Fixed charges, consisting of depreciation, taxes, and insurance, are figured as follows: depreciation for equipment, 10 percent a year of erected equipment cost; for building, 3 percent a year of building costs (land not depreciated); taxes and insurance, 3 percent a year of estimated fixed capital investment.

Wages and salaries are estimated as follows: operators, $5.50 an hour; assistant or semiskilled operators, $4.00 an hour; supervisory help, 15 percent of labor costs; and payroll overhead, 25 percent of the base pay for labor and supervision.

The hypothetical plants for these estimates are equipped for sanitary operations and, in some instances, may include a clean-in-place (CIP) system. In an installation where a CIP system can be used, cleaning of equipment can be accomplished without dismantling it, thereby reducing labor requirements. A CIP system consisting of tanks, pumps, heat exchangers, and accessory items can be automated to various degrees to simplify operations.

Costs for treatment of waste streams and materials that are discharged from the various processes have not been included in the cost estimates. However, such costs cannot be ignored and for some locations may be a critical factor in determining the overall feasibility of installing a process.

Information supplied by DeLaval Separator Company, Poughkeepsie, N.Y., was helpful in preparing cost estimates for isolated soy protein and soy protein concentrate. Wenger Manufacturing, Sabetha, Kan., provided cost information on the production of full-fat soy flour and textured soy protein.

Production on Full-Fat Soy Flour by Extrusion Cooking

Extrusion has been adapted (Mustakas and others, 1964, 1970) in a system for cooking whole soybeans to obtain a full-fat soy flour of the highest quality for human consumption. By this method, a bland and palatable product with excellent nutritive value and good stability can be obtained. Oil cells of the seed are "ruptured" in the extrusion process due to the levels of temperature, pressure, and moisture existing in the barrel of the extruder. The extrusion cooking is performed in an extruder-screw configuration as shown in figure 6. During passage through the various sections, the material is gradually subjected to increased pressure and temperature. Finally, maximum pressure is created in the metering section. Temperature is partially controlled by steam jackets. Heat, of course, is also developed by screw pressure on solids during extrusion. Temperature of meal in the metering section reaches values above atmospheric boiling; however, boiling does not take place because the force is above atmospheric pressure. Thus, the extruder section is acting as a continuous pressure cooker. When the material extrudes through the final die or small apertures, the sudden great reduction in pressure causes the material to expand, thus rupturing the cells. This transformation of the material has been responsible for the process being called the "extrusion or expansion process." A similar process is being used in making cereal-type breakfast foods, as well as pet foods.

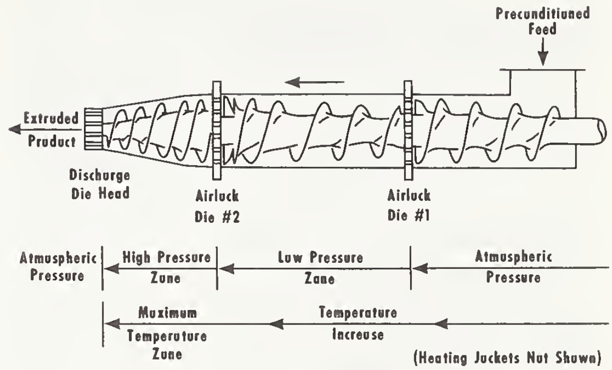

Figure 6.—Extruder screw standard configuration.

Figure 7 gives the sequence of operation for the continuous process of making full-fat soybean flour by extrusion cooking. First steps involve cracking, dehulling, flaking, and preconditioning of the raw material before extruding. Critical parts of the whole process are preconditioning, extrusion-cooking, and drying. Figure 8 shows the equipment layout arrangement for these operations. Flours of high nutritive value and good stability can be prepared by preheating unextruded soy bean flakes or grits to 200 to 212°F., premixing and adding sparge steam at 212°F., adjusting the moisture content to 18 to 21 percent, using a transport time of 1 to 1.5 minutes in the extruder with a final extrusion temperature reaching 250 to 290°F., and then drying, cooling, and grinding.

Estimated processing costs, excluding costs for soybeans, for a plant producing 4 tons per hour of full-fat soy flour (24,000 tons annually) from dehulled beans are 0.6 cent a pound of flour or 33 cents a bushel of whole beans. Fixed capital investment for such a plant is estimated at $200,000. This figure does not include the cost for land and building, storage facilities, and equipment for bean preparation. However, a charge for receiving and preparing the beans is added to the processing costs (table 11). Predicted yield is 90 pounds of full-fat soy flour from 100 pounds of whole beans. If soybeans are available at $6.00 a bushel ($0.10 a pound), estimated production

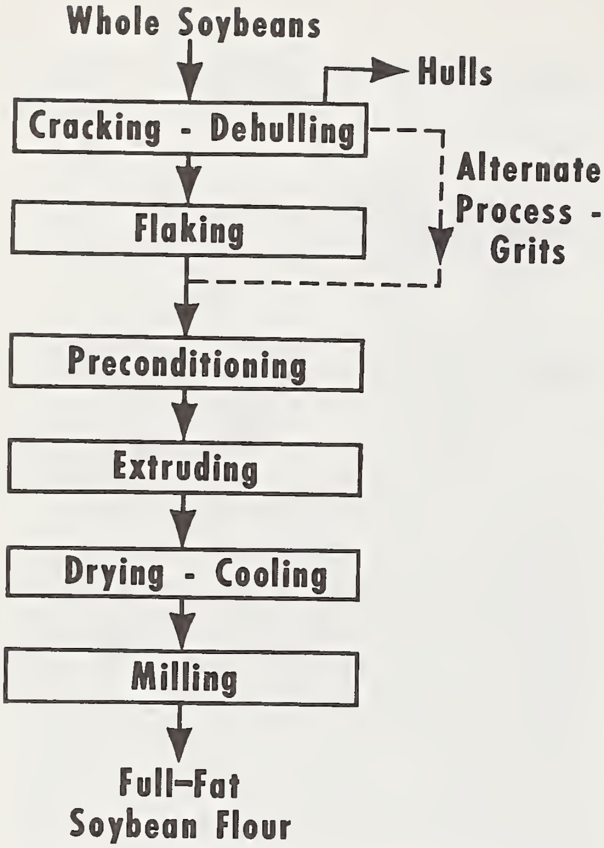

Figure 7.—Continuous extrusion process for the production of full-fat soy flour.

Table 11—Estimated processing costs per ton for producing full-fat soy flour by extrusion cooking of dehulled soybeans, 1974

Cost item	Dollars per ton of flour
Utilities:	
Steam: 2,600 lb, @ $1 a 1,000 lb	2.60
Electricity: 41 kWh, @ $0.025 a kWh	1.03
Water	Nominal
Labor and supervision:	
3 operators, @ $5.50 an hr	1.38
6 helpers, @ $4 an hr	2.00
Supervision	.50
Payroll overhead	.97
Maintenance and repairs, 5% a yr on $200,000	.42
Fixed charges:	
Depreciation, 10% a yr on $200,000	.83
Taxes and insurance, 3% a yr on $200,000	.25
Charge for receiving, grinding, and dehulling beans (1.1 tons)	2.50
Estimated processing costs per tons of flour	12.48
Estimated processing costs per lb of flour	.0062
Estimated processing costs per bushel of beans	.33

Notes

Cost of soybeans not included.
Plant capacity: 24,000 tons a year (96 tons a day).
Operations are conducted 24 hours a day 250 days a year.
Yield of flour: 90 pounds per 100 pounds of soybeans.
Estimated fixed capital investment: $200,000.
Estimated fixed capital investment does not include cost of land and building, facilities for steam and power generation, bean storage and preparation, product grinding and storage, and packaging.

costs, not including byproduct credit for hulls removed, are 11.7 cents per pound of flour.

Production of Defatted Soy Flour and Grits

Defatted soy flour and grits are the most elementary forms of high soy protein, yet they are the soy products used in the largest volume in foods. Only fully toasted or heat-treated flour and grits will be considered here. Products with minimum heat treatment are used directly for special purposes or for production of protein isolate.

When preparing soy flour and grits for human consumption, the soybeans should be thoroughly cleaned by standard procedures necessitating more than one cracking for complete separation of hulls (fig. 9) (De, S. S., 1971). Heating should be conducted under carefully controlled conditions to (1) secure optimum flavor and palatability, and (2) completely inactivate objectionable antibiological factors, unless the end-use requires retention of a high level of protein solubility or enzyme activity. Heating must not be so drastic as to damage the protein or reduce its nutritive value to unacceptable levels. Once optimum improvement in the factors noted above is effected, the desolventized toasted flakes should be cooled quickly to ambient temperatures. The fully processed flakes should have a light golden yellow color and a toasted and bland flavor, separate and distinct from that characteristic of raw soybeans. The product may be supplied in the form of grits (for example, a product that will pass through a 20-mesh screen and be retained on a 50-mesh

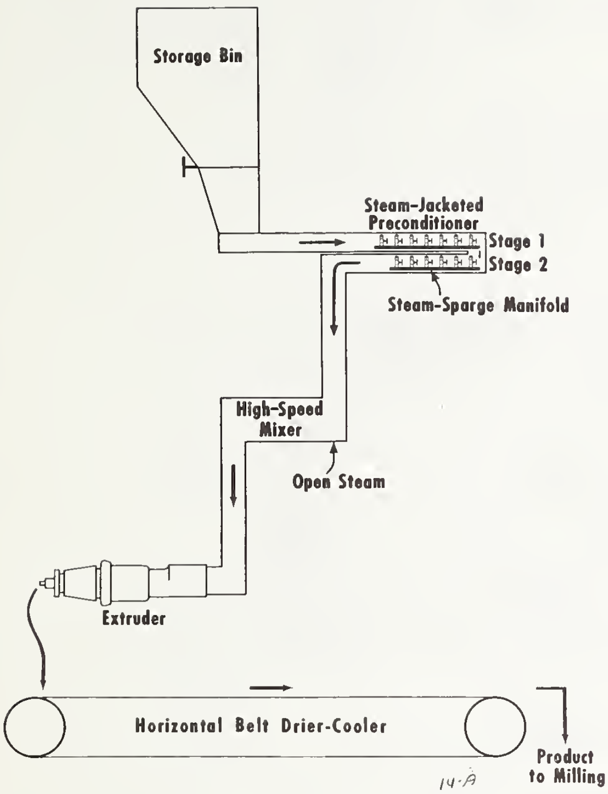

Figure 8.—Equipment layout for preconditioning, extruding, cooling, and drying steps.

screen) or ground to flour (97 percent will pass through a 100-mesh screen).

The minimum economic unit for a solvent extraction plant in foreign countries is considered to be 30 to 50 tons of beans a day, whereas in the United States, minimum capacity is about 150 tons a day.

Pretreatment.—All edible soybean products are derived from clean sound beans. Beans when received contain about 11 percent moisture and varying quantities of impurities.

The first processing step is to pass the beans through an aspirator/sieve cleaner which separates the incoming material into cleaned beans and trash (fig. 9). The cleaned beans are then dried to about 10 percent moisture. The beans next pass through a cracking process, where fluted rolls reduce the whole bean to fragments one-sixth to one-eighth of the original bean size. These fragments are then graded on sieves into two sizes, each stream passing through aspirators where the hulls are separated from the meal. The separated hulls are toasted and ground and used for animal feed. The cleaned, cracked meats now pass to a conditioner-cooker from which they emerge at a temperature of about 170°F. with a moisture content of 10 percent. This prepares them for flaking; flaking takes place between rollers, and the flakes emerge at a thickness of 0.008 to 0.010 inch. Flaking breaks down cell walls and makes available greater surface area for action of the solvent in the extraction process.

Extraction.—Solvent extraction (fig. 10) involves soaking oil-bearing material in a suitable solvent. The oil is dissolved in the solvent to form a mixture called miscella, which drains from the meal. The oil-rich miscella is evaporated to recover the oil and solvent. The meal is desolventized to yield a product with low oil and high protein content.

Solvent extraction is generally a continuous flooded process, the process being divided into stages to avoid back mixing of weaker and richer miscellas. This division allows almost continuous flooding with through stages of countercurrent washes to improve extraction efficiency.

The extractor is generally made up of a series of cells or baskets that rotate about a vertical axis. Each cell has an automatically operated outlet door fitted with a drainage screen. The raw material enters the extractor through a specially designed sealing feed screw and travels in the cell around the extractor. It is discharged through another automatically operated sealing device. During its passage around the extractor, the material is continuously soaked in a countercurrent segregated system of diminishing miscella strengths and finally washed with clean solvent. Soaking periods are adjusted to suit the materials being processed. The rotational speed of the extractor can be varied and the position of each miscella wash can be adjusted by the operator to suit different materials or different circumstances.

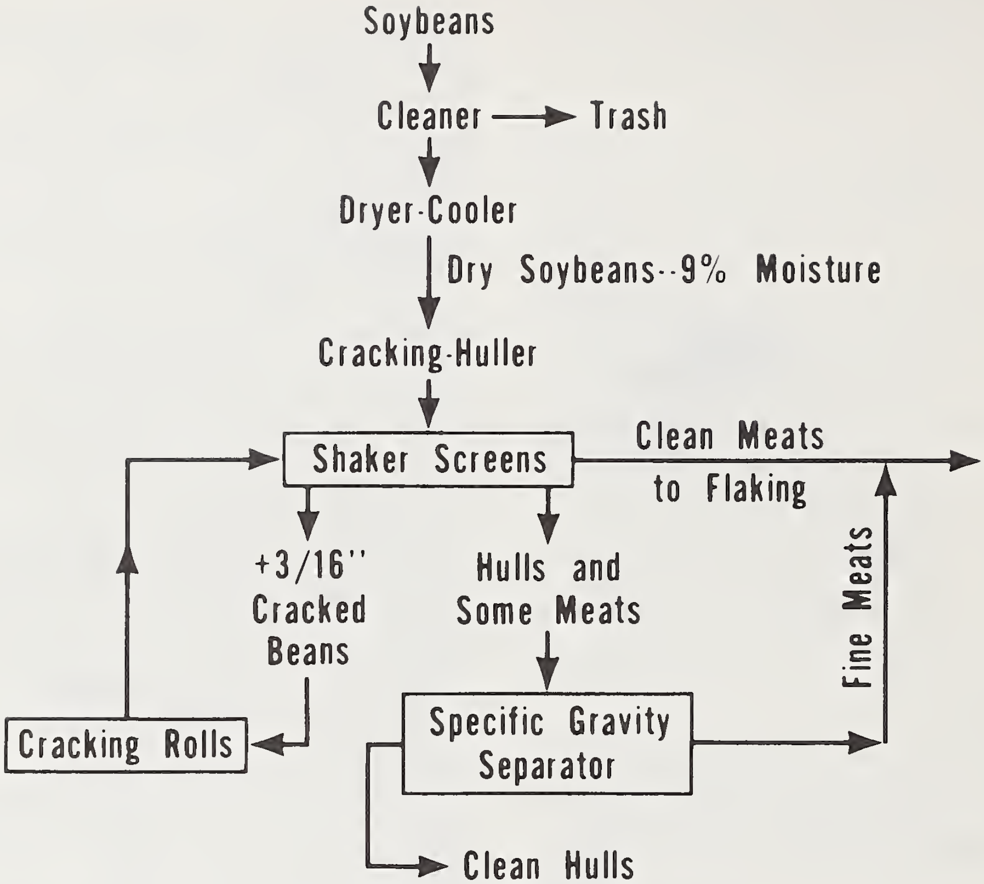

Figure 9.—Soybean dehulling installation.

Any fine particles that drain out of the cell bottom with the miscella are returned via a stage pump to the flooding device at the top of the extractor and recycled to the top of the cell. Clean filtered miscella leaves the bottom of each cell.

Desolventizing.—Desolventizing extracted soy flakes involves three simultaneous operations: elimination of solvent, destruction of urease, and toasting of the meal (giving it a golden-brown appearance). This necessitates the use of a desolventizer-toaster (DT) which combines the operations in a single unit. Flakes coming out of the extractor are defatted but still wet with solvent; they enter the upper compartment of the DT through a rotary valve or a similar device. Here they are in contact with steam either coming from the lower compartment or directly injected in the upper compartment.

The steam condenses on the flakes, evaporating the impregnated solvent at the same time. This evaporation is rather fast and practically all the solvent is eliminated in the second compartment. At this point, the moisture content of the flakes reaches 20 to 25 percent. The main purpose of the following compartments is to cook the flakes in a humid atmosphere that results in destruction of antinutritional factors. The time required for cooking is reduced by increases in temperature and moisture content. The purpose of the lower compartments is to reduce moisture to obtain the standard 12 to 13 percent moisture normally required for bagging. This is the conventional way of treating extracted soybean meal and it easily yields meals with a urease activity (the inactivation of urease by moist heat provides a quality control guide to deter-

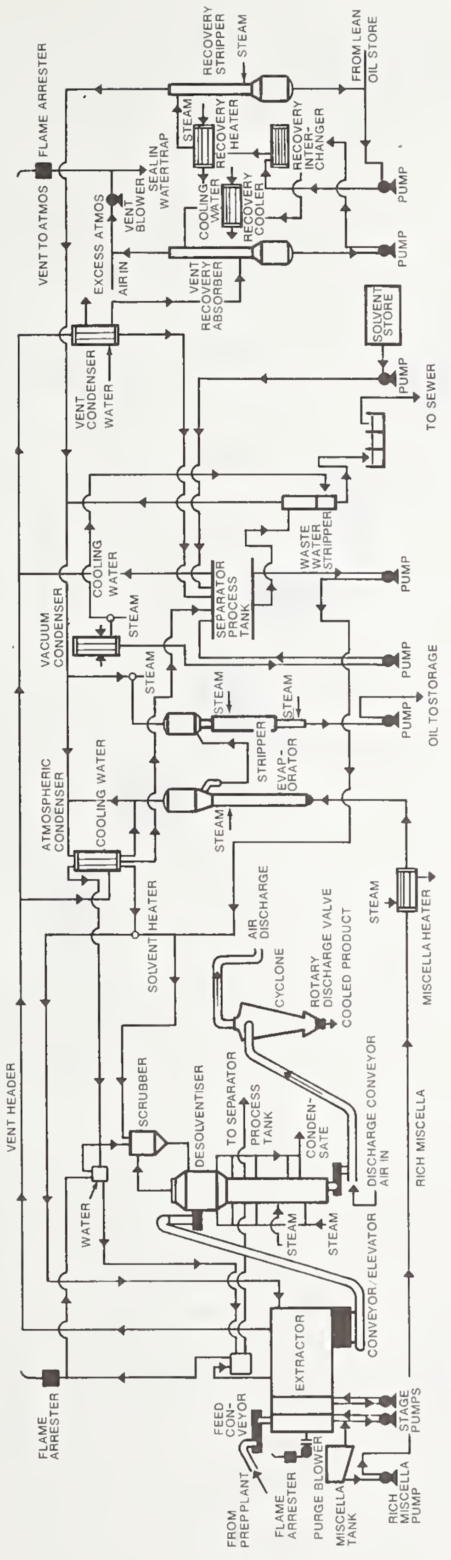

Figure 10.—Continuous solvent extraction plant.

mine the degree of heat treatment) under 0.02 (pH method).

Vapor Scrubbing.—Entrained fine solid particles in the vapor are removed by washing with solvent in a scrubbing device. The small amount of solvent used, plus entrained fines, is returned to the desolventizer.

Estimated Cost.—An estimate of the cost for preparing edible defatted flour and grits in a soybean processing plant has not been reported and cost information based on actual plant experience for the production of defatted flour and grits is not readily available. Processing costs in a soybean plant producing oil and meal for feed by the usual commercial procedure have been reported at about 25 cents a bushel of beans. If alterations were made in such a plant to permit production of edible defatted flour and grits also, it is expected that processing costs would increase but a few cents a bushel of beans.

Soy Protein Concentrate

The procedure described below was patented by Sair (1959, U.S. Patent No. 2,881,076) assigned to the Griffith Laboratories, Inc., and is based on extraction of defatted soybean meal with water at the isoelectric point of the protein (pH 4.6). Other processes are also in use.

An equipment flow diagram for this process is shown in figure 11. The procedure for producing soy protein concentrate is as follows:

Eleven hundred pounds of defatted soy flour are slurried into 1,400 gallons of cold water in a stainless steel tank. To this is added 66 pounds of HCl (37 percent by weight); the pH of the mixture is 4.6. After being agitated for 1 hour, the mass is centrifuged for separation of the curd and whey. The curd is washed twice by being resuspended in cold water with agitation as before and recentrifuged. The curd is an isoelectric residue and it may be dried for certain uses, or further treated as follows: To each 500 gallons of curd, raised in temperature to 110° to 120°F., is slowly added an aqueous solution of caustic soda, requiring about 12 to 14 pounds of NaOH, to raise the pH to 6.7 to 7.1. The neutralized con-

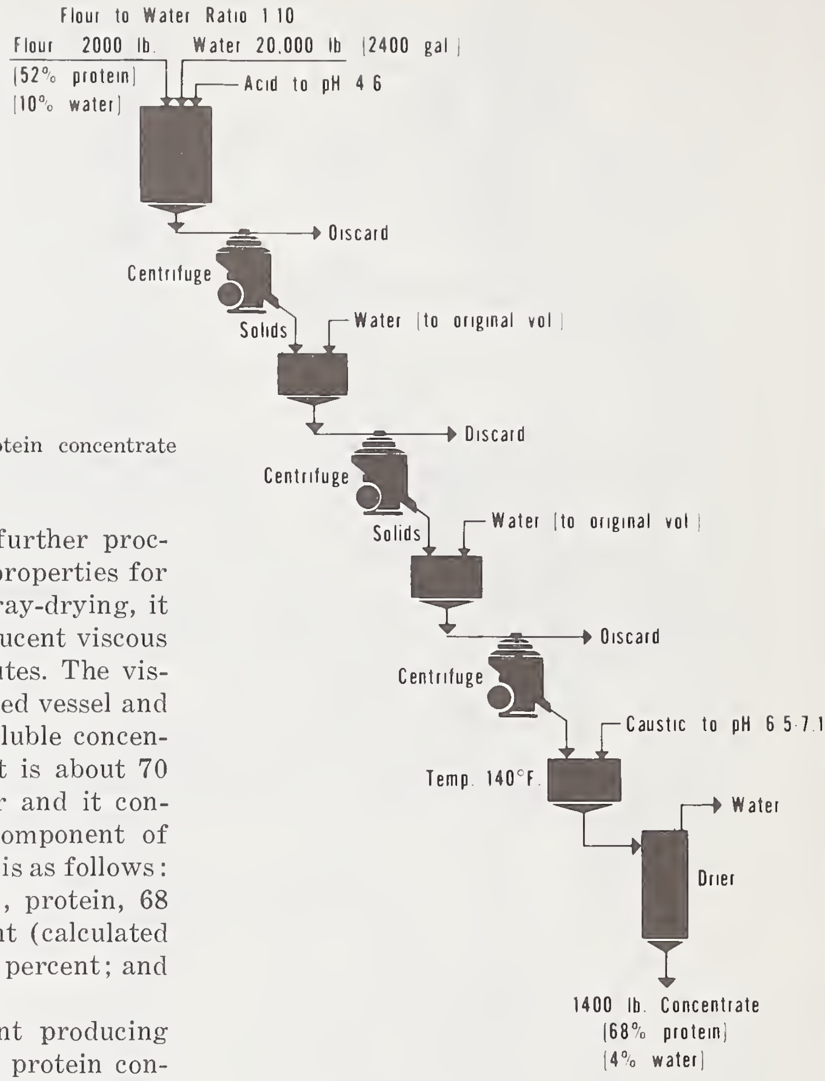

Figure 11.—Flowsheet for soy protein concentrate production.

centrate may be dried without further processing. However, to improve its properties for certain uses and to facilitate spray-drying, it is heated to 140°F. until a translucent viscous fluid is formed in about 30 minutes. The viscous fluid is drawn from the heated vessel and spray-dried to form a readily soluble concentrate. The yield of dried product is about 70 percent of the original soy flour and it contains 3.6 percent lysine as a component of protein. Typical product analysis is as follows: Moisture 3 percent (by weight), protein, 68 percent; reducing sugar, 1 percent (calculated as anhydrous dextrose); ash, 5.5 percent; and fat, 0.1 percent.

Estimated Costs.—For a plant producing 30 tons a day of neutralized soy protein concentrate (7,500 tons per year) from defatted soy flour, the estimated cost of production is about 25 cents a pound of concentrate, when defatted flour is 12 cents a pound (table 12). Estimated fixed capital investment for such a plant is about $4 million (table 13). Yield of concentrate has been predicted at 70 pounds from 100 pounds of flour when operations are conducted according to the procedure shown in figure 11. Costs for treatment of waste streams in the process would be in addition to the above costs.

Protein Isolate

Commercial production of protein isolate from soybeans for industrial uses began in Chicago in 1935 and has steadily increased since then. The industry was and still is primarily concerned with manufacturing adhesives for coating paper and other applications. The first plant producing edible grade soy protein isolate began operations in 1959. Since then, many developments have been reported on its uses in foods (De, S. S., 1971).

Although large quantities of both edible and industrial grades of soy protein isolate are currently produced in the United States, little published information exists on specification of design, equipment, and operation of the plants. Large-scale commercial know-how is limited to a few industrial organizations and several patents have been taken on the isolation of soy protein in its native state as well as

Table 12—Cost of producing neutralized soybean protein concentrate (68 to 70 percent protein) from defatted soybean flour (52 percent protein)

Cost item	Daily cost	Cost of concentrate
	Dollars	*Cents per lb.*
Raw materials:		
Defatted soy flour: 85,700 lb, @ $0.12 a lb	10,284.00	
Caustic: 935 lb, @ $0.13 a lb.	121.55	
Hydrochloric acid: 5,142 lb, @ $0.02 a lb	102.84	
	10,508.39	17.5
Utilities:		
Steam	Nominal	
Water (treated): 225,000 gal, @ $0.25 a 1,000 gal	56.25	
Electricity: 12,500 kwh @ $0.025 a kwh	312.50	
Gas 720,000 ft^3, @ $1 a 1,000 ft^3	720.00	
	1,088.75	1.8
Labor and supervision		
10 operators: @ $5.50 an hr	440.00	
3 helpers: @ $4 an hr	96.00	
Supervision: 15 percent of direct labor	80.40	
Payroll overhead	154.10	
	770.50	1.3
Maintenance		
Equipment: 5 percent a yr on $3,600,000	720.00	
Land and building: 2 percent a yr on $400,000	32.00	
	752.00	1.2
Fixed charges:		
Depreciation:		
Equipment: 10% a yr on $3,600,000	1,440.00	
Building: 3% a yr on $350,000	42.00	
Taxes and insurance: 3% a yr on $4,000,000	480.00	
	1,962.00	3.3
Estimated daily production costs	15,081.64	
Estimated production costs		25.1

Notes

Plant capacity: 7,500 tons a year (30 tons a day) when operations are conducted 24 hours a day 250 days a year.
Yield of concentrate: about 70 pounds per 100 pounds of defatted soybean flour.

Table 13—Fixed capital investment for a plant producing 7,500 tons a year (30 tons a day) of soy protein concentrate (68 to 70 percent protein) from defatted soybean flour (52 percent protein)[1]

Cost item	Dollars
Equipment, delivered	
6 continuous centrifuges, stainless steel for sanitary operations	750,000
1 spray dryer with auxiliaries for sanitary operations	325,000
Mixing tanks, stainless steel	160,000
Pumps, centrifugal and positive displacement	6,900
Clean-in-place system	22,000
Miscellaneous equipment	23,500
Total delivered equipment cost	1,287,400
Erected equipment cost	3,600,000
Land and building	400,000
Estimated fixed capital investment	4,000,000

[1] Yield of concentrate: About 70 pounds per 100 pounds of defatted soybean flour.

Note

Operating schedule: 24 hours a day, 250 days a year.

on improving flavor and functional characteristics for various uses.

Apart from sanitary conditions, production, and marketing, many differences exist between the isolate produced for food and that for industrial uses. Food-grade soy protein isolate is prepared with minimum chemical modification, ensuring no significant loss of amino acids or nutritional value. Protein isolate for industrial applications is generally modified by alkali or other chemical treatments which may lead to degradation of proteins and certain essential amino acids.

Advantages of Protein Isolation.—In addition to its high protein content, the isolated protein has a number of other advantages. Elimination of the insoluble and partly indigestible carbohydrate fraction results in removal of substances with undesirable physical characteristics; this fraction has a marked swelling tendency and makes any food into which it is incorporated bulky. In addition,

isolation of protein removes many odoriferous and bitter elements that affect palatability and also harmful substances, such as trypsin inhibitors, hemagglutinins, etc., that impair the digestibility and utilization of the proteins.

Soy meal for protein isolation must have a high protein solubility. Unit operations in the commercial extraction of soybean oil with low boiling hydrocarbon solvents, usually hexane, have been discussed in the section on preparation of defatted flours. Very little denaturation occurs in the first stages of the solvent extraction stage. In most plants, some denaturation occurs in the desolventizer stage, but maximum changes take place in the steaming and toasting stages for improving flavor and nutritional value of the meal.

The high temperature in the toaster, in the presence of moisture, denatures the proteins and makes the meal unsuitable for protein isolation. Flash-type and vapor-phase desolventizers are found to be most suitable for producing meals with a high protein solubility or nitrogen dispersibility index (90 percent) (Milligan and others, 1974; Becker, K. W., 1971).

Solubilization of Protein from the Meal and Isolation.—About 92 percent of the protein from defatted soybean meal can be extracted with distilled water at a pH of 6.6. Contrary to the behavior of most vegetable proteins, low concentrations of salts reduce the dispersion of soy protein. For example, 0.1 normal sodium chloride in water lowers the dispersion from 92 percent to 45 percent and 0.0175 normal calcium or magnesium chloride lowers the dispersion of nitrogen components to 21 percent. This effect is overcome by increasing the concentration of salt or by raising the pH of the system. Most industrial sources of water are too high in salt concentration to give good yields of extracted protein and alkali has to be used to overcome the salt effect. In commercial practice, alkali dispersion at moderate pH and temperature levels is adopted to solubilize the protein, though acid dispersion at optimal pH range can also be used to disperse the protein. To ensure a high yield of protein, the meal is extracted with water at about pH 9.0. The insoluble residue in the dispersion, constituting nearly a third of the meal, is removed in a centrifuge and the protein precipitated with acid in the pH range of 4.6 to 4.1. In laboratory-scale operations, as much as 84 percent of the total protein of the meal may be recovered. Thus, with defatted meal containing 50 percent protein, the yield is 42 percent on the weight of the meal. In large-scale processing, however, yields are considerably lower, partly because of the lower water-to-meal ratio used in commercial processing. A yield of 30 percent on meal weight may be considered satisfactory under commercial conditions.

Factors Affecting the Extraction and Isolation of Protein from Meal.—Several factors, such as the nature of the extractant (solvent), pH, salts, extraction time and temperature, meal-to-extractant ratio, particle size of the meal, agitation, and the like, influence the dispersion characteristics of the nitrogenous constituents of the meal and are of paramount importance for optimal yield of the isolate in processing.

High yields of the isolate have been obtained by adjusting the pH of the extractant to about 9.0. The pH of the solution should be above 6.8, regardless of the dispersing agents used. The dispersibility of protein rises gradually, with increase reaching a maximum yield at about pH 11.0. Recent patents, however, prescribe a pH range of 7.0 to 7.6 for the extract.

The influence of low concentrations of salts (univalent and divalent cations) on the nitrogen dispersion behavior has been discussed in the previous section. It is, however, interesting to note that at the same pH, the isolated unhydrolyzed native protein is considerably less soluble in water than the original protein of the defatted meal. This difference has been attributed to the presence of potassium phosphate, dialyzable salts, and lecithin in the soybean meal and also to partial denaturation of protein during isolation. The behavior of phytin (a Ca-Mg salt of phytic acid believed to form complexes with soy protein) has been studied with respect to the isolation of the protein. Of the total phosphorus in soybeans, 70 percent exists in the form of phytin; the defatted meal contains nearly all the original

phosphorus present in the beans. The solubility of phosphorus compounds in water extract of soybean meal varies with the pH of the solution like that of the major protein components. Phytin can be eliminated from the water extract of the meal by a combination of dialysis and treatment with anion exchange resins. Such treatment helps to obtain a high degree of purity in the isolated protein and several patents exist on the use of ion exchange resins for this purpose.

It has been reported that for the temperature range of 15° to 80° C., the total nitrogen extracted increased by about 0.25 percent per degree, and that the extraction reaches a maximum value at 80°C. In several patents, temperatures in the range of 55° to 60°C. have been specified. The amount of nitrogen extracted increased steadily in the first 30 minutes, reaching a nearly constant level after 45 minutes. Variations from 15 minutes to 2 hours are generally used industrially. Obviously, the extraction time and temperature are related to other factors, such as agitation, particle size, meal-to-extractant ratio, and other engineering and economic considerations.

Although large volumes of extractant may facilitate complete extraction of protein, their use in practice within specific time schedules poses many difficult engineering problems. For large-scale production, the most economic ratio is selected on the basis of the process for production of the meal, protein, and process cost. Generally, meal-to-extractant ratios in the range of 1:10 to 1:20 are recommended. Two successive extractions at 1:10 and 1:5 ratios are also used.

The particle size of soybean meal has a marked effect on the extraction efficiency. A mesh size of 100 or above is recommended for maximum extraction of protein. However, in the case of flake-type defatted soybean meal, the rate of extraction of protein is not very much affected by particle size.

Grinding soybean meal into fine particle size may increase or reduce the solubility of nitrogen, depending on the nature of milling action and the resultant heat of friction, if any. Dry grinding in a ball mill is known to exert a denaturing effect, probably due to the heat developed by the pounding action of the balls. However, wet grinding is very effective in increasing the water solubility of the protein.

The rate of extraction is obviously increased by agitation; however, moderate agitation to keep the meal freely suspended in the dispersion is sufficient for efficient extraction.

Separation of the insoluble residue from the aqueous alkaline dispersion presents many difficulties in large-scale operations. The coarse insoluble residue can be removed by passing the extract through an 80-mesh vibrating screen. Fine particles passing through the screen are removed in a continuous discharge-type centrifuge. Separation cannot be effected by filtration because of mucilaginous substances present.

Foaming during agitation or pumping generally leads to a decrease in the effective operating volumes of storage tanks and vessels. Steam-jets, ultrasonic vibrations, and mechanical devices of various kinds have been used to suppress foam. Often the use of antifoaming agents is essential. These include silicones, higher alcohols, and solutions of detergents in animal, vegetable, and mineral oils. Foam-detecting devices regulating automatic addition of antifoaming agents may be attached to the vessels.

Precipitation of the Extracted Protein.—Although a number of methods and protein precipitants are available, food-grade acids, commonly hydrochloric acid and acetic acid, are used for production of edible protein isolate. The type of acid used to lower the pH of the extract does not affect yield of protein. Precipitation of protein with calcium chloride has also been reported.

Soybean Whey.—The filtrate or centrifugate from wet protein curd contains water-soluble components of the meal, including albumins, proteoses, peptones, nonprotein nitrogen, sugars, trypsin inhibitors, urease, lipoxygenases, and other enzymes. This solution is known as "soybean whey" and its solids constitute about one-third of the original meal. Although several components of whey may have potential value, economic methods for their recovery have not yet been developed.

Some companies prefer to concentrate, dry, and add whey solids to animal feeds.

Washing of Protein Curd.—After acid precipitation, washing the protein curd is essential to remove acid and eliminate whey components. Two washing steps are recommended. Aqueous alcohols have also been used as washing media for special purposes.

Dewatering and Drying Proteins.—A vacuum drum filter is used to separate protein curd from whey, but for large continuous operation, automatic desludging centrifuges offer many advantages. The present-day practice is to use partial desludging centrifuges of the self-opening type or decanters to obtain a protein precipitate with as little whey as possible. The sludge obtained with a moisture content varying from 60 to 80 percent is spray-dried to yield the isoelectric form or neutralized with food grade alkali and spray-dried to yield the proteinate form. Some difficulties have been encountered in spray-drying, due to high viscosity of soy protein suspension, requiring precise control of process variables for ensuring good operation.

Yield and Quality of Protein Isolate.—Various literature references indicate that protein yields in the range of 30 to 40 percent of the weight of the defatted flake used can be obtained. Sound process design requires sanitary construction in stainless steel with both manual and automatic cleaning systems. Attention must be given to sanitary process control to prevent microbial growth and contamination.

Spray-dried protein isolate is a cream-white product, having a low flavor intensity, compared with other soy protein products. The flavor of isolated soy protein is often described as "cooked cereal-like" with certain off-notes. The proximate analysis of several commercial isolates is given in table 5 in the section, Kinds of Soy Products.

The process procedure and types of equipment required as suggested by Alfa-Laval for production of protein isolate are described in the followin section, and used as the basis for estimating production costs.

Alfa-Laval Process Procedure

Generalities.—A number of problems must be considered in selecting equipment for an ISP (isolated soy protein) plant (fig. 12); most important among these probably is the necessity of maintaining adequate hygienic standards.

All equipment has to be designed to make cleaning simple and efficient and to reduce manual labor; an automatic CIP (cleaning in place) system is particularly recommended to make sure that cleaning will be effective and correct.

Separation Equipment.—Separators are the most important components of an ISP processing plant.

Separators must produce a well-clarified effluent (that is, process liquid) and a solids phase containing the minimum of moisture so that losses are as low as possible and that drying the byproduct feed is economical.

One type of separator that seems to meet these diversified requirements is a solids-ejecting centrifugal separator with special modifications to suit this particular application. Experience has shown that separators of this type can be used to advantage for every kind of separation operation used in ISP processing and they also offer the advantages of using only one type of separator. The Alfa-Laval product line includes a number of separators that may be used for this purpose. Three models will be discussed here: a small pilot-plant separator (BRPX 207), a normal factory-size machine (BRPX 213) with three to four times greater throughput capacity, and a big factory separator (BRPX 317) with a throughput capacity about twice that of the BRPX 213.

Discharge of the solids phase from the separator is initiated ("triggered") either by a timer or by a self-sensing system that releases an impulse to empty the rotor ("bowl"). Being more sophisticated in design (and also somewhat more expensive), the latter system is insensitive to variations in the concentration of solids in the feed, producing a sediment of constant dryness along with a clean effluent. A particular advantage of this system is that it reduces losses and improves the economy of drying the byproduct feed.

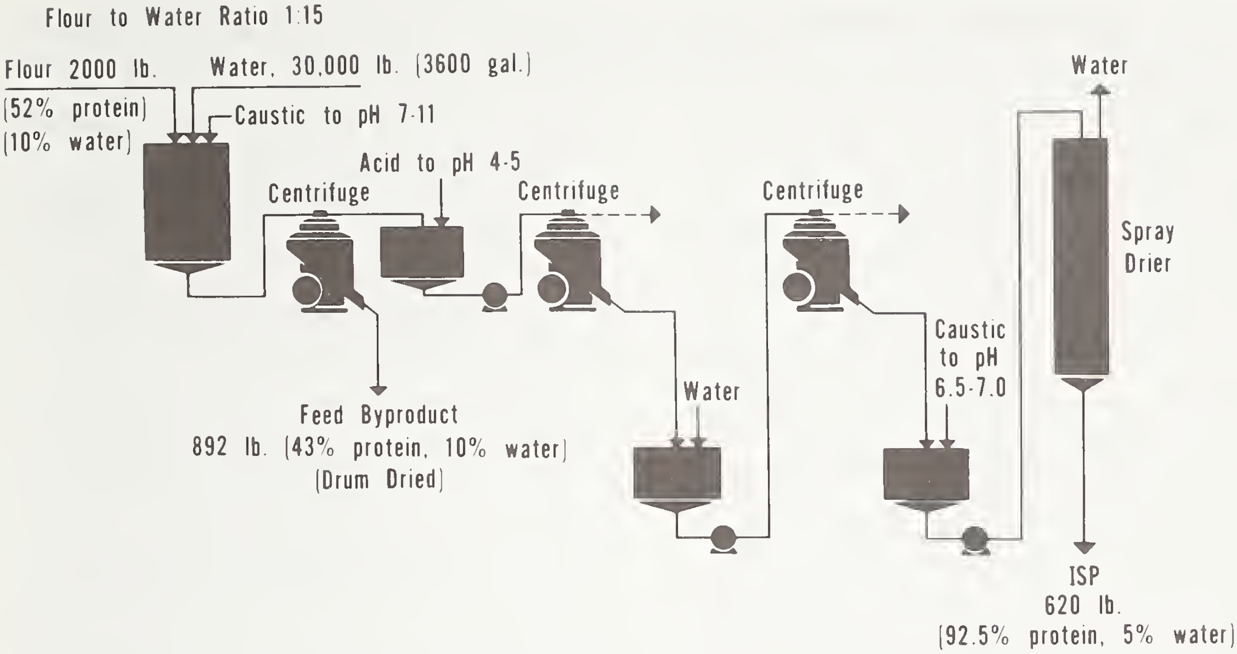

Figure 12.—Flowsheet for isolated soy protein production (ISP).

Tanks.—The tanks must have smooth surfaces and have to be designed to enable the cleaning liquid to flow at the speed required for efficient cleaning everywhere in the tanks. Pickups and agitators must be designed to exclude any pockets in which dirt would accumulate, yet facilitate efficient agitation without squashing any particles, which would complicate the subsequent separation process.

Pumps, Pipes, and Fittings.—Pipes, pumps, and valves have to be of sanitary design and must be arranged in such a way that there will be no pockets in which liquid might be trapped.

CIP.—A CIP plant is required, composed of tanks, pumps, valves, heat exchangers, and equipment to control the entire cleaning program.

Spray-Dryer for ISP.—The drying temperature has to be low and facilities for rapid cooling of the dried product are needed. In addition, the dryer should be easy to clean.

Dryer for Byproduct.—A drum dryer is suggested for drying the byproduct feed. The drying temperature is decisively important to the nutritional value of the product as well as to drying costs.

Processing Stages.—Basically, the ISP process is a batch process, meaning that you fill a tank, carry out a reaction, separate and remove the products obtained, and start a new batch.

Not only time but also pH and temperature influence the quality of the ISP product. In addition to affecting yield, these parameters greatly influence the performance of the separators and dryers. The amount of liquid used for alkaline extraction is important, whether one or two such extraction stages are pre-

ferred, as determined by the market prices of ISP and the byproduct feed, as well as the demands for quality and protein content of the latter.

A considerable amount of carbohydrates is dissolved and is present in the solution occluded in the acid precipitated curd. If a product rich in protein and poor in carbohydrate is desired, the curd must be washed, which inevitably leads to some loss of protein.

Process Design and Possibilities of Development.—A number of alternative possibilities exist for combining various components into a complete plant; the smallest conceivable plant is a pilot plant with a number of tanks arranged about a pilot-plant-size centrifugal separator used for the three necessary separation stages. It is possible, theoretically, to let such a plant expand by adding a similar centrifuge in each separation stage but the costs associated with the CIP and control systems will be just as high as in a big plant.

Starting with a factory-size separator, however, the pilot plant may be expanded at a later stage by the incorporation of two additional separators, thus developing it into a commercial production plant of the smallest size that may be expected to work at a profit. In a plant as described, each processing stage will include a tank and a separator. The following equipment will also have to be included in the plant: a neutralization tank, storage tanks with equipment for proportioning chemicals, pumps, pipes and fittings, and a CIP plant. A production plant of this design would have an output of about 2,200 pounds of ISP each 24 hours when working three shifts.

By adding more than one tank to each separator, the separators may be run continuously, increasing the plant output about three times.

When applying this system, the CIP may be carried out according to either of two methods: (1) the entire plant is stopped and remains inoperative during cleaning, or (2) a more complicated system is adopted in which certain parts of the plant are cleaned while others are operative. In the latter case, it will be necessary to include equipment for digital sequential control, but several hours of production will be gained every day, making the more complicated system more profitable. It will, in fact, pay for itself within a short period of time.

The plant output may be further increased by either of the following methods:

1. By arranging several processing lines in parallel, with certain equipment in common, such as the CIP and control equipment.

2. By employing several separators and tanks in parallel in each processing stage, with certain equipment in common, as mentioned above.

The latter solution offers the cheapest way of extending the plant. Sufficient space has to be reserved from the beginning, however. In principle, any throughput capacity may be chosen because centrifugal separators of a variety of sizes are available; the general rule is, however, that the fewer components, the less expensive the plant. In big plants, it is advantageous to use big tanks, with a number of subsequent separators in parallel. This also makes for the simplest CIP system.

Spray-drying is an expensive operation, demanding considerable investment; therefore, much attention has to be paid to the drying system of an ISP plant. Sometimes the isolate produced may be used directly in the moist state, provided that storage time is not excessive and that low-temperature storage can be provided.

In planning drying operations, it should be remembered that neither the feed byproduct dryer nor the ISP dryer can be extended step-by-step at a future expansion of the plant and that the only possibility of increasing the drying capacity is to increase the time of operation.

Estimated Costs.—A cost estimate for producing isolated soy protein by the process described and shown in figure 12 illustrates that, in a plant producing 20 tons per day of ISP (5,000 tons a year), the net cost to make it, including byproduct feed estimate of 9.4 cents a pound of ISP, is about 45 cents a pound. Defatted flour is assumed to be available to the process at 12 cents a pound. Calculations are based on a predicted yield of 31 pounds ISP per 100 pounds of flour and a byproduct feed recovery of about 45 pounds per 100 pounds of flour. Byproduct feed is priced at

Table 14—Cost of producing isolated soy protein (92 to 93 percent protein) from defatted soybean flour (52 percent protein)

Cost item	Daily cost	Cost of concentrate
	Dol.	*Cents per lb.*
Raw materials:		
Defatted soy flour: 129,000 lb., @ $0.12 a lb.	15,480.00	38.7
Caustic: 675 lb., @ $0.13 a lb.	87.75	.2
Hydrochloric acid	Nominal	......
Utilities:		
Steam: 175,000 lbs., @ $1 a 1,000 lbs.	175.00	
Water (treated): 385,000 gals. a day @ $0.25 a 1,000 gals.	96.25	
Electricity: 17,000 kWh @ $.025 a kWh	425.00	
Gas: 576,000 cu. ft. @ $1 a 1,000 cu. ft.	576.00	
	1,272.25	3.2
Labor and supervision:		
16 operators @ $5.50 an hr.	704.00	
3 helpers @ $4 an hr.	96.00	
Supervision @ 15% of direct labor	120.00	
Payroll overhead	230.00	
	1,150.00	2.9
Maintenance and supplies		
Equipment 5% a yr. on $4,900,000	980.00	
Land and building: 2% a yr. on $600,000	48.00	
	1.028.00	
Fixed charges:		
Depreciation:		
Equipment: 10% a yr. on $4,900,000	1,960.00	
Building: 3% a yr. on $540,000	64.80	
Taxes and insurance: 3% a yr. on $5,500,000	660.00	
	2,684.80	
Estimated daily production cost	21,702.80	
Estimated gross production cost		54.3
Byproduct credit: feed fractions, 1.45 lb. (65 per lb.) per lb. of ISP		9.4
Estimated net production cost, cents per lb. of ISP		44.9

Notes

Plant capacity: 5,000 tons a year (20 tons a day) of ISP when operations are conducted 24 hours a day, 250 days a year.
Yield of ISP per 100 pounds of defatted flour is about 31 pounds.
Yield of feed fraction per 100 pounds of defatted flour is about 45 pounds (43 to 44 percent protein).

Table 15—Fixed capital investment for a plant producing 5,000 tons a year (20 tons a day) of isolated soy protein (92 to 93 percent protein) from defatted soybean flour (52 percent protein)[1]

Cost item	Cost
	Dollars
Equipment, delivered:	
9 continuous centrifuges, stainless steel, for sanitary operations	1,125,000
1 spray dryer with auxiliaries, for sanitary operations, for drying ISP	126,000
2 drum dryers with auxiliaries, for drying feed fraction	290,000
Mixing tanks, stainless steel	185,000
Pumps, centrifugal and positive displacement	12,000
Clean-in-place system	25,000
Miscellaneous equipment—bins, scales, etc.	30,000
Total delivered equipment cost	1,793,000
Erected equipment cost	4,900,000
Land and building	600.000
Estimated fixed capital investment	5,500,000

[1] Yield of ISP: about 31 lb from 100 lbs of defatted soybean flour.

Note

Operating schedule: 24 hours a day, 250 days a year.

$130 a ton or 6.5 cents a pound (table 14). Estimated fixed capital investment for such a plant is $5,500,000 (table 15).

This process requires the treatment of several waste streams containing both suspended and dissolved solids, but costs for such treatment are not a part of the cost estimate. Whether actual recovery of solids from waste streams is economically feasible is problematical but will depend in part on pollution constraints or charges for sewage treatment.

Extrusion-Expanded Products—Textured Soy Proteins

Extrusion-expanded products — textured soy proteins—consist essentially of defatted oilseed flours, grits, meals, or flour-concentrate blends which have been subjected to HTST (high temperature short time) process-

ing. The textured materials are usually available in dry form as flavored or bland, simple or compound products.

The essential characteristic of this process is that soy flours (about 50 percent protein) are used as the starting material. This plus greater simplicity of extrusion gives the process a cost advantage over the spinning (Boyer) process which uses isolated soy protein. A cooker-extruder is used to force the thermoplastic protein material through a die that controls the size and shape of the texturized material.

In operation (fig. 13), the extrusion is quite simple, but does require considerable experience in the handling of the equipment. Soybean meal that is substantially oil-free—about 0 to 5 percent by weight—is used. This meal is premoistened to levels of 15-40 percent, with special additives (such as salt and alkali) sometimes added to the preconditioning water. The mixture is agitated until homogenous. It is then fed to the extruder while the screw is rotated at a substantial speed. Steam and water are used in alternate jacket sections for heating and cooling. Cooling is usually carried out near the feed section of the extruder. The meal mixture is advanced within the extruder while being heated to high temperatures and subjected to elevated pressures. The mechanically worked mixture becomes a viscous fluid-type substance that is forced through a restrictor orifice after 30 to 60 seconds' retention time in the extruder. As the product emerges from the die outlet, the superheated moisture contained in the meal enters the substantially lower atmospheric pressure environment where flash-off evaporation of part of the moisture expands the product into a porous structure. Evaporation also cools the product substantially. The expanded product is very porous and has a fibrous network structure somewhat resembling that of meat. The product can be kept moist and used directly for food materials, or can be dried and packed conveniently for later use.

It rehydrates rapidly and completely within a few seconds, merely by adding water (usually about two parts for one part solids) to yield a product with excellent food characteristics.

Estimated Costs.—Cost of production of textured soy protein (TSP) by extrusion cooking of defatted flour has been estimated at 13 cents a pound when flour is priced at 12 cents a pound. This cost is based on a plant producing 2 tons of TSP an hour, or 12,000 tons a year. Estimated fixed capital investment—excluding cost for land and building, compounding and mixing systems, product storage, and packaging equipment—is $400,000 (table 16). In the cost calculations, it was assumed that no material was lost during processing. The cost would be increased appropriately if flavoring and other ingredients, such as coloring agents and vitamins or other nutrients, were added.

Table 16—Cost of producing textured soy protein (TSP, 20 lb. a cu. ft.) by extrusion cooking of defatted soy flour

Cost item	Dollars per ton of TSP [1]
Raw materials:	
Defatted soy flour, 2,000 lbs. @ $0.12 a lb.	240.00
Utilities:	
Steam: 3,500 lb. @ $1 a 1,000 lbs.	3.50
Electricity: 122 kWh @ $0.625 a kWh	3.05
Water	Nominal
Labor and supervision:	
3 operators @ $5.50 an hr.	2.75
6 helpers @ $4 an hr.	4.00
Supervision	1.01
Overhead	1.94
Maintenance and repairs: 5% a yr. on $400,000	1.67
Fixed charges:	
Depreciation: 10% a yr. on $400,000	3.33
Taxes and insurance: 3% a yr. on $400,000	1.00
Estimated cost of production per ton of TSP	262.25
Estimate cost of production, cents per lb. of TSP	13.1

[1] Assumes no loss of material during processing.

Notes

Plant capacity: 12,000 tons a year of TSP (48 tons a day).
Operations are conducted 24 hours a day, 250 days a year.
Estimated fixed capital investment is $400,000. Does not include cost for land and building, steam and power generating facilities, compounding and mixing systems, product storage, packaging, and similar items.

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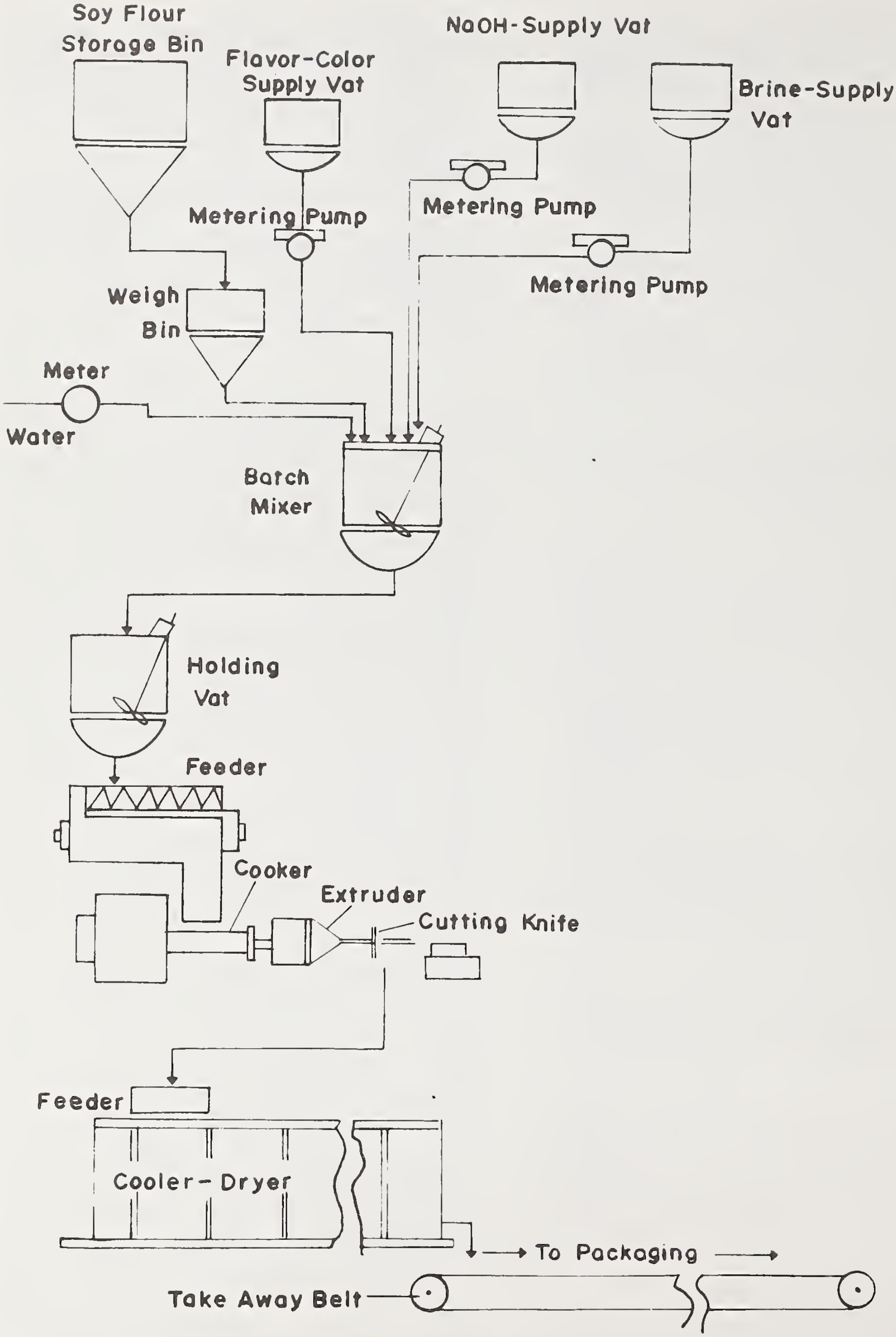

Figure 13.—Flowsheet for production of textured soy protein (Courtesy of *Food Engineering*).

CURRENT GOOD MANUFACTURING PRACTICE[1]

Assuring a high standard of sanitation in plants processing products for human consumption has been a U.S. Government policy of long standing. Current good manufacturing practice is the starting point for any sanitation program relative to food processing. The Food and Drug Administration describes this practice as a requirement of the Food, Drug, and Cosmetic Act. The most recent good manufacturing practice was published April 26, 1969, in the Federal Register and is reproduced here for basic guidance.

The Food and Drug Administration is studying the conditions applying to the production of edible soy protein to determine whether or not additional Federal regulation setting forth more specific sanitary standards are needed. There is uncertainty as to how soon this work will be complete. The practice reproduced here is, therefore, the most current guidance available.

§ 128.1 Definitions.

The definitions and interpretations contained in section 201 of the Federal Food, Drug, and Cosmetic Act are applicable to such terms when used in this part. The following definitions shall also apply:

(a) "Adequate" means that which is needed to accomplish the intended purpose in keeping with good public health practice.

(b) "Plant" means the building or buildings or parts thereof, used for or in connection with the manufacturing, processing, packaging, labeling, or holding of human food.

(c) "Sanitize" means adequate treatment of surfaces by a process that is effective in destroying vegetative cells of pathogenic bacteria and in substantially reducing other micro-organisms. Such treatment shall not adversely affect the product and shall be safe for the consumer.

§ 128.2 Current good manufacturing practice (sanitation).

The criteria in §§ 128.3 through 128.8 shall apply in determining whether the facilities, methods, practices, and controls used in the manufacture, processing, packing, or holding of food are in conformance with or are operated or administered in conformity with good manufacturing practices to assure that food for human consumption is safe and has been prepared, packed, and held under sanitary conditions.

§ 128.3 Plant and grounds.

(a) *Grounds.* The grounds about a food plant under the control of the operator shall be free from conditions which may result in the contamination of food including, but not limited to, the following:

(1) Improperly stored equipment, litter, waste, refuse, and uncut weeds or grass within the immediate vicinity of the plant buildings or structures that may constitute an attractant, breeding place, or harborage for rodents, insects, and other pests.

(2) Excessively dusty roads, yards, or parking lots that may constitute a source of contamination in areas where food is exposed.

(3) Inadequately drained areas that may contribute contamination to food products through seepage or foot-borne filth and by providing a breeding place for insects or micro-organisms.

If the plant grounds are bordered by grounds not under the operator's control of the kind described in subparagraphs (1) through (3) of this paragraph, care must be exercised in the plant by inspection, extermination, or other means to effect exclusion of pests, dirt, and other filth that may be a source of food contamination.

(b) *Plant construction and design.* Plant buildings and structures shall be suitable in size, construction, and design to facilitate maintenance and sanitary operations for food-processing purposes. The plant and facilities shall:

(1) Provide sufficient space for such placement of equipment and storage of materials

[1] Amendment published in Federal Register: Part 128—Human Foods; Current Good Manufacturing Practice, April 26, 1969; 34 F.R. 6977.

as is necessary for sanitary operations and production of safe food. Floors, walls, and ceilings in the plant shall be of such construction as to be clean and in good repair. Fixtures, ducts, and pipes shall not be so suspended over working areas that drip or condensate may contaminate food, raw materials, or food-contact surfaces. Aisles or working spaces between equipment and between equipment and walls shall be unobstructed and of sufficient width to permit employees to perform their duties without contamination of food or food-contact surfaces with clothing or personal contact.

(2) Provide separation by partition, location, or other effective means for those operations which may cause contamination of food products with undesirable micro-organisms, chemicals, filth, or other extraneous material.

(3) Provide adequate lighting to hand-washing areas, dressing and locker rooms, and toilet rooms and to all areas where food or food ingredients are examined, processed, or stored and where equipment and utensils are cleaned. Light bulbs, fixtures, skylights, or other glass suspended over exposed food in any step of preparation shall be of the safety type or otherwise protected to prevent food contamination in case of breakage.

(4) Provide adequate ventilation or control equipment to minimize odors and noxious fumes or vapors (including steam) in areas where they may contaminate food. Such ventilation or control equipment shall not create conditions that may contribute to food contamination by airborne contaminants.

(5) Provide, where necessary, effective screening or other protection against birds, animals, and vermin (including but not limited to, insects and rodents).

§ 128.4 Equipment and Utensils.

All plant equipment and utensils should be (a) suitable for their intended use, (b) so designed and of such material and workmanship as to be adequately cleanable, and (c) properly maintained. The design, construction, and use of such equipment and utensils shall preclude the adulteration of food with lubricants, fuel, metal fragments, contaminated water, or any other contaminants. All equipment should be so installed and maintained as to facilitate the cleaning of the equipment and of all adjacent spaces.

§ 128.5 Sanitary facilities and controls.

Each plant shall be equipped with adequate sanitary facilities and accommodations including, but not limited to, the following:

(a) *Water supply.* The water supply shall be sufficient for the operations intended and shall be derived from an adequate source. Any water that contacts foods or food-contact surfaces shall be safe and of adequate sanitary quality. Running water at a suitable temperature and under pressure as needed shall be provided in all areas where the processing of food, the cleaning of equipment, utensils, or containers, or employee sanitary facilities require.

(b) *Sewage disposal.* Sewage disposal shall be made into an adequate sewerage system or disposed of through other adequate means.

(c) *Plumbing.* Plumbing shall be of adequate size and design and adequately installed and maintained to:

(1) Carry sufficient quantities of water to required locations throughout the plant.

(2) Properly convey sewage and liquid disposable waste from the plant.

(3) Not constitute a source of contamination to foods, food products or ingredients, water supplies, equipment, or utensils or create an insanitary condition.

(4) Provide adequate floor drainage in all areas where floors are subject to flooding-type cleaning or where normal operations release or discharge water or other liquid waste on the floor.

(d) *Toilet facilities.* Each plant shall provide its employees with adequate toilet and associated hand-washing facilities within the plant. Toilet rooms shall be furnished with toilet tissue. The facilities shall be maintained in a sanitary condition and kept in good repair at all times. Doors to toilet rooms shall be self-closing and shall not open directly into areas where food is exposed to airborne contamination, except where alternate means have been taken to prevent such contamination (such as

double doors, positive air-flow systems, etc.) Signs shall be posted directing employees to wash their hands with cleaning soap or detergents after using toilet.

(e) *Hand-washing facilities.* Adequate and convenient facilities for hand washing and, where appropriate, hand sanitizing shall be provided at each location in the plant where good sanitary practices require employees to wash or sanitize and dry their hands. Such facilities shall be furnished with running water at a suitable temperature for hand washing, effective hand-cleaning and sanitizing preparations, sanitary towel service or suitable drying devices, and, where appropriate, easily cleanable waste receptacles.

(f) *Rubbish and offal disposal.* Rubbish and any offal shall be so conveyed, stored, and disposed of as to minimize the development of odor, prevent waste from becoming an attractant and harborage or breeding place for vermin, and prevent contamination of food, food-contact surfaces, ground surfaces, and water supplies.

§ 128.6 Sanitary Operations.

(a) *General maintenance.* Buildings, fixtures, and other physical facilities of the plant shall be kept in good repair and shall be maintained in a sanitary condition. Cleaning operations shall be conducted in such a manner as to minimize the danger of contamination of food and food-contact surfaces. Detergents, sanitizers, and other supplies employed in cleaning and sanitizing procedures shall be free of significant microniological contamination and shall be safe and effective for their intended uses. Only such toxic materials as are required to maintain sanitary conditions for use in laboratory testing procedures, for plant and equipment maintenance and operation, or in manufacturing or processing operations shall be used or stored in the plant. These materials shall be identified and used only in such manner and under conditions as will be safe for their intended uses.

(b) *Animal and vermin control.* No animals or birds, other than those essential as raw material, shall be allowed in any area of a food plant. Effective measures shall be taken to exclude pests from the processing areas and to protect against the contamination of foods in or on the premises by animals, birds, and vermin (including, but not limited to, rodents and insects). The use of insecticides or rodenticides is permitted only under such precautions and restrictions as will prevent the contamination of food or packaging materials with illegal residues.

(c) *Sanitation of equipment and utensils.* All utensils and product-contact surfaces of equipment shall be cleaned as frequently as necessary to prevent contamination of food and food products. Nonproduct-contact surfaces of equipment used in the operation of food plants should be cleaned as frequently as necessary to minimize accumulation of dust, dirt, food particles, and other debris. Single-service articles (such as utensils intended for one-time use, paper cups, paper towels, etc.) should be stored in appropriate containers and handled, dispensed, used, and disposed of in a manner that prevents contamination of food or food-contact surfaces. Where necessary to prevent the introduction of undesirable microbiological organisms into food products, all utensils and product-contact surfaces of equipment used in the plant shall be cleaned and sanitized prior to such use and following any interruption during which such utensils and contact surfaces may have become contaminated. Where such equipment and utensils are used in a continuous production operation, the contact surfaces of such equipment and utensils shall be cleaned and sanitized on a predetermined schedule using adequate methods for cleaning and sanitizing. Sanitizing agents shall be effective and safe under conditions of use. Any facility, procedure, machine, or device may be acceptable for cleaning and sanitizing equipment and utensils if it is established that such facility, procedure, machine, or device will routinely render equipment and utensils clean and provide adequate sanitizing treatment.

(d) *Storage and handling of cleaned portable equipment and utensils.* Cleaned and sanitized portable equipment and utensils with product-contact surfaces should be stored in such a location and manner that product-con-

tact surfaces are protected from splash, dust, and other contamination.

§ 128.7 Processes and controls.

All operations in the receiving, inspecting, transporting, packaging, segregating, preparing, processing, and storing of food shall be conducted in accord with adequate sanitation principles. Overall sanitation of the plant shall be under the supervision of an individual assigned responsibility for this function. All reasonable precautions, including the following, shall be taken to assure that production procedures do not contribute contamination such as filth, harmful chemicals, undesirable micro-organisms, or any other objectionable material to the processed product:

(a) Raw material and ingredients shall be inspected and segregated as necessary to assure that they are clean, wholesome, and fit for processing into human food and shall be stored under conditions that will protect against contamination and minimize deterioration. Raw materials shall be washed or cleaned as required to remove soil or other contamination. Water used for washing, rinsing, or conveying of food products shall be of adequate quality, and water shall not be reused for washing, rinsing, or conveying products in a manner that may result in contamination of food products.

(b) Containers and carriers of raw ingredients should be inspected on receipt to assure that their condition has not contributed to the contamination or deterioration of the products.

(c) When ice is used in contact with food products, it shall be made from potable water and shall be used only if it has been manufactured in accordance with adequate standards and stored, transported, and handled in a sanitary manner.

(d) Food-processing areas and equipment used for processing human food should not be used to process nonhuman food-grade animal feed or inedible products unless there is no reasonable possibility for the contamination of the human food.

(e) Processing equipment shall be maintained in a sanitary condition through frequent cleaning including sanitization where indicated. Insofar as necessary, equipment shall be taken apart for thorough cleaning.

(f) All food processing, including packaging and storage, should be conducted under such conditions and controls as are necessary to minimize the potential for undesirable bacterial or other microbiological growth, toxin formation, or deterioration or contamination of the processed product or ingredients. This may require careful monitoring of such physical factors as time, temperature, humidity, pressure, flow-rate and such processing operations as freezing, dehydration, heat processing, and refrigeration to assure that mechanical breakdowns, time delays, temperature fluctuations, and other factors do not contribute to the decomposition or contamination of the processed products.

(g) Chemical, micro-biological, or extraneous-material testing procedures shall be utilized where necessary to identify sanitation failures or food contamination, and all foods and ingredients that have become contaminated shall be rejected or processed to eliminate the contamination where this may be properly accomplished.

(h) Packaging processes and materials shall not transmit contaminants or objectionable substances to the products, shall conform to any applicable food additive regulation (Part 121 of this chapter), and should provide adequate protection from contamination.

(i) Meaningful coding of products sold or otherwise distributed from a manufacturing, processing, packing, or repacking activity should be utilized to enable positive lot identification to facilitate, where necessary, the segregation of specific food lots that may have become contaminated or otherwise unfit for their intended use. Records should be retained for a period of time that exceeds the shelf life of the product, except that they need not be retained more than 2 years.

(j) Storage and transportation of finished products should be under such conditions as will prevent contamination, including development of pathogenic or toxigenic micro-organisms, and will protect against undesirable deterioration of the product and the container.*

§ 128.8 Personnel.

The plant management shall take all reasonable measures and precautions to assure the following:

(a) *Disease control.* No person affected by disease in a communicable form, or while a carrier of such disease, or while affected with boils, sores, infected wounds, or other abnormal sources of microbiological contamination, shall work in a food plant in any capacity in which there is a reasonable possibility of food or food ingredients becoming contaminated by such person, or of disease being transmitted by such person to other individuals.

(b) *Cleanliness.* All persons, while working in direct contact with food preparation, food ingredients, or surfaces coming into contact therewith shall:

(1) Wear clean outer garments, maintain a high degree of personal cleanliness, and conform to hygienic practices while on duty, to the extent necessary to prevent contamination of food products.

(2) Wash their hands thoroughly (and sanitize if necessary to prevent contamination by undesirable micro-organism) in an adequate hand-washing facility before starting work, after each absence from the work station, and at any other time when the hands may have become soiled or contaminated.

(3) Remove all insecure jewelry and, during periods where food is manipulated by hand, remove from hands any jewelry that cannot be adequately sanitized.

(4) If gloves are used in food handling, maintain them in an intact, clean, and sanitary condition. Such gloves should be of an impermeable material except where their usage would be inappropriate or incompatible with the work involved.

(5) Wear hair nets, headbands, caps, or other effective hair restraints.

(6) Not store clothing or other personal belongings, eat food or drink beverages, or use tobacco in any form in areas where food or food ingredients are exposed or in areas used for washing equipment or utensils.

(7) Take any other necessary precautions to prevent contamination of foods with micro-organisms or foreign substances including, but not limited to, perspiration, hair, cosmetics, tobacco, chemicals, and medicants.

(c) *Education and training.* Personnel responsible for identifying sanitation failures or food contamination should have a background of education or experience, or a combination thereof, to provide a level of competency necessary for production of clean and safe food. Food handlers and supervisors should receive appropriate training in proper food-handling techniques and food-protection principles and should be cognizant of the danger of poor personal hygiene and insanitary practices.

(d) *Supervision.* Responsibility for assuring compliance by all personnel with all requirements of this Part 128 shall be clearly assigned to competent supervisory personnel.

§ 128.9 Exclusions.

The following operations are excluded from coverage under these general regulations; however, the Commissioner will issue special regulations when he believes it necessary to cover these excluded operations: Establishments engaged solely in the harvesting, storage, or distribution of one or more raw agricultural commodities, as defined in section 201 (r) of the act, which are ordinarily cleaned, prepared, treated or otherwise processed before being marketed to the consuming public.

MARKET GROWTH

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Various factors have helped to establish present markets for soybean proteins and also will influence the growth of future markets:

1. Economics
2. Growth of processed foods market
3. Flavor characteristics
4. Functional properties
5. Nutritional properties
6. Government regulations
7. Consumer acceptance

Not all of these determinants of growth are of equal importance, but some of them are interrelated. For example, flavor of a protein ingredient can have a favorable or unfavorable effect on consumer acceptance. On the other hand, if Government regulations prohibit or severely limit protein additives in a particular food, low price and excellent functional properties are of little or no importance.

Economic Factors

Soybean proteins are ingredients for processed foods and, therefore, compete with other protein sources used for this purpose, particularly animal proteins such as milk and egg proteins. Economics is one of the strongest forces influencing future markets because, if other factors such as flavor and functionality are equal, manufacturers will select the lowest cost ingredient. Economics is often the wedge that opens doors to new markets. In many instances, soybean proteins do not meet all the desired criteria for complete replacement of a higher priced protein, but partial substitution is possible and is made. This in turn leads to further improvement of the desired qualities and to modification of formulations with the result that ultimately more of the animal protein is displaced. For example, one company now markets a partial egg yolk replacer that contains modified vegetable proteins and is intended for the bakery trade. Use of this product is probably still small. However, with time and a continued favorable price differential between egg yolks and the replacer, the market is likely to grow because the bakers have an incentive to use the product, and the ingredient supplier is encouraged to make further improvements in the properties of the alternate protein.

Milk Proteins Versus Soybean Proteins.—The economic advantage of soybean proteins over animal proteins is clearly shown by comparing soybean proteins with those from milk. Selling prices per pound of ingredient as well as per pound of protein and annual consumption figures for the two protein groups are given in table 17. Flours and grits, the soybean products of lowest protein content, are higher in protein than all of the milk proteins except casein. Indeed, flours and grits sell for about the same price as whey but contain four times as much protein.

Table 17—Domestic consumption, protein content and prices of milk and soy proteins used for processed foods

Protein	Consumption [1]	Protein content	Bulk price per lb. [2]	Price per lb. of protein
	Million lb.	*Pct.*	*Dol.*	*Dol.*
Milk:				
Nonfat dry milk	1,056	36	0.57	1.59
Dry whole milk	21	26	0.63	2.42
Casein	85	95	0.90-1.20	0.95-1.26
Whey	231	13	0.11-0.15	0.85-1.15
Soybean:				
Flours and grits	150	50	0.11-0.14	0.22-0.28
Concentrates	55	70	0.30-0.38	0.43-0.54
Isolates	50	95	0.58-0.64	0.61-0.67
Textured flours	90	50	0.21-0.24	0.42-0.48
Textured isolates	20	20 [3]	0.50+	2.50+

[1] Data for 1973. Milk protein data, except casein figure, from U.S. Dept. Agr., Econ. Res. Serv., Dairy Situation (1974). Soy protein figures estimated from Lockmiller (1975) assuming that all concentrate and isolate production is consumed domestically.
[2] Approximate prices January 1975. Low price for casein is for acid form and high price is for sodium caseinate.
[3] Frozen, 60 percent moisture basis.

Nonfat dry milk has been in short supply and has more than tripled in price over the past few years with the result that it is too expensive to use as a normal bread ingredient (Cotton, 1974; Singleton and Robertson, 1974). Bakers have, therefore, begun replacing nonfat dry milk in baked goods with various soy-derived ingredients, including blends of: cheese whey, whey protein, soy flour plus vitamins and minerals; cheese whey, soy flour, and buttermilk; and cheese whey, sodium caseinate, soy protein isolate, and soy flour. These and related milk replacers are also used by other food processors who have traditionally used nonfat dry milk. It is unlikely that nonfat dry milk will drop to its former low price; hence, soybean products can be expected to take increasing portions of this market in the future. Nonetheless, the present high-volume market for nonfat dry milk (table 17), despite its high price, indicates that soybean products now available may not be satisfactory replacements for many applications. It will, therefore, be necessary to develop desired qualities in the soybean products if they are to be successful in displacing the milk product.

Casein is another example of an animal protein that has priced itself out of certain markets. When casein is compared with its soybean counterpart, the isolates, we see that sodium caseinate (the principal form of casein used in processed foods and selling at $1.20 a pound) sells at almost twice the price of the soybean product. Virtually all of the casein used domestically is imported, and there are no trends toward lower prices in the near future. Consequently, substitution of soybean protein isolates for sodium caseinate has occurred in items such as liquid coffee whiteners, instant breakfast products, and whole milk powder replacers. These trends will undoubtedly continue in the future as flavor and functional properties of soybean concentrates and isolates are further modified and improved.

Growth of Processed Foods Market

Processed foods are predicted to grow continually for the next several decades. Because soybean proteins are used extensively in these products, markets for soybean-based ingredients are also expected to grow substantially. Table 18 shows projected growth of protein utilization in processed foods to 1980 as estimated by Hammonds and Call (1972) based on an extensive survey made in 1970. This projection includes the portion of processed foods also referred to as fabricated foods. Bread, ice cream, and margarine are fabricated foods of long standing, whereas textured vegetable proteins, coffee whiteners, and instant breakfast items are examples of recently developed products of this type. Fabricated foods are made from ingredients of various sources to supply fat, protein, and carbohydrates, plus a number of minor additives as needed. Increasingly, fabricated foods are designed from the outset to include soybean proteins to take advantage of the economies involved.

Table 18—Protein use, 1969, and growth in use, projected 1980

Use	Annual growth rate	Protein 1969	Protein 1980
	Pct.	*Ml. lb.*	
Baby food	1.0	3.5	3.9
Baked goods and baking needs:			
Snack food	6.0	10.0	19.0
All other	1.5	91.0	107.1
Breakfast food:			
Instant breakfast	8.0	12.8	29.8
All other	1.7	5.1	6.2
Candy	3.0	16.6	23.0
Canned and processed meat	19.3	92.2	642.4
Coffee whitener	6.0	12.0	22.8
Dairy products:			
Imitation milk	......	......	188.0
Synthetic ice cream	5.0	3.8	6.5
All other	1.0	98.1	109.1
Desserts and toppings	6.0	31.7	60.0
Diet drink	2.0	8.4	10.5
Frozen food	3.6	3.8	5.6
Macaroni/pasta products	3.0	1.5	2.1
Pet food	5.4	[1] 229.3	426.0
Soup	0.0	1.5	1.5
Subtotal		621.3	1,663.5
All other uses	9.3 [2]	207.3	555.0
Total		828.6	2,218.5

[1] Includes 51.9 million lb. from ingredients not fit for human consumption.
[2] Weighted average growth rate for all protein ingredients.
Source: Hammonds and Call (1972).

The most rapidly growing portion of the protein market is in processed meats. Because of the volume of meats involved, this is also

predicted to be the largest market for protein ingredients. About one-half of the growth is expected to be in meat extenders and the other half in meat analogs.

Table 19 shows predictions of growth for fabricated foods for the next 5 years. The sector projected to grow most rapidly is vegetable protein products, although many products in other categories may already contain some form of soybean protein (for example, dairy substitutes, dietetic foods, and prepared cereals). A projection of uses for textured vegetable proteins according to markets and by types (extruded flour versus textured isolates) is given in table 20. At present, extruded flour is the major product type sold, and most of it is being consumed by school food services. However, predictions are that the spun type of product will become the predominant form sold and that large increases in usage will occur in public eating and commercial outlets. A large untapped market in the institutional trade consists of nursing homes, convalescent centers, and hospitals where meat analogs could be used in controlled diets with standardized caloric, nutrient, and salt compositions (Robinson, 1972).

Three years ago only one textured vegetable protein product (fried bacon-like chips) had made significant penetration of the consumer market. The next major introduction of textured products in the retail markets came in 1973 when beef prices rose to high levels and ground beef-textured soybean protein blends were offered at $0.10 to $0.20 a pound below ground meat prices. Consumer acceptance of the blends was good (about 25 percent of total ground meat sales) until beef prices declined again. In late 1974, the market of the beef-soybean blends was estimated to have dropped to about 15 percent of ground meat sales (Brudnak, 1974). The textured products derived from soy flour are also available in the supermarkets in a dry form for use in the home, but sales of these items are probably small. It is likely that more sophisticated and appealing products must be offered in the retail outlets before large markets become established. One company moved in this direction in 1974 by introducing frozen analogs of pork sausage and ham slices (Brudnak, 1974). More recently this same company also introduced a frozen sliced bacon analog and another firm is test marketing a refrigerated bacon analog (Anon., 1974).

Table 19—Sales of fabricated foods, 1972 and projections for 1976 and 1980

Food for human consumption	Sales in— 1972	1976	1980
	Million dollars		
Dairy substitutes	847.4	994.2	2,527.4
Beverages	157.3	211.8	273.9
Snack foods	2,001.8	2,467.3	3,066.1
Prepared desserts	60.0	82.0	111.0
Salad dressings:			
Spoonable	313.6	370.9	439.2
Pourable	122.6	172.0	238.1
Vegetable protein products	82.0	316.5	1,531.9
Dietetic foods	39.5	47.7	96.0
Prepared cereals	670.0	753.0	848.0
Cookies and crackers	1,558.0	1.686.0	1,825.0
Cake and roll mixes	230.5	240.6	250.4
Breakfast bar products	68	86	109.0
Total	6,150.7	7,428.0	11,316.0

Source: Frost and Sullivan, Inc., New York, "The Fabricated Foods Market," cited by Iammartino (1974).

Table 20—Market projections for textured vegetable proteins, selected years, 1975-2000

	Use in— 1975	1980	1985	1990	2000
	Million pounds				
School lunch	113	180	210	270	348
Public eating	28	352	1,095	1,968	2,372
Federal institutions	12	27	40	58	79
Commercial and others	35	1,248	3,139	7,423	9,413
Total	188	1,807	4,484	9,719	12,212
Extruded type	117	1,066	2,107	3.888	4,885
Spun type	71	741	2,377	5,831	7,327
	Million dollars				
Sales [1]					
Extruded	47	426	843	1,554	1,954
Spun	64	667	2,139	5,247	6,594

[1] Assumes average price (constant through 2000) for extruded is $0.40/lb; spun, $0.90/lb.
Source: Business Communications Co., cited by Iammartino (1974).

Flavor Characteristics

Flavor has been a major deterrent to use of soybean proteins in a variety of foods. Improvements are being made, however, and it is likely that progress will continue. A growing number of companies are working on the problem; with the present economic advantage of soybean proteins over milk and other animal

proteins, it is also possible to use more complex (and expensive) processes to obtain products with less residual soybean flavor. As the flavor problem becomes better understood, one can anticipate changes in the overall processing of soybeans. At present, the protein portion of the business is basically an upgrading of a byproduct from oil extraction; that is, defatted flakes. Eventually, processing may be modified to put the emphasis on quality of the protein rather than the oil.

Functional Properties

Proteins have many different properties, and as the food industry developed, certain proteins were found to have unique characteristics ideally suited for certain applications. Examples are the baking properties of wheat gluten and the whipping properties of egg whites. Because of such specific functional properties, it is often difficult to replace some proteins. Sodium caseinate in powdered coffee whiteners has successfully resisted replacement because of its emulsification properties and stability to curdling in hot coffee. Nonetheless, soy protein is now used successfully in some frozen coffee whiteners; vulnerability of sodium caseinate in coffee whiteners is therefore greater than believed just a few years ago.

The properties of proteins can be altered extensively by processing, such as heat treatment, alcohol extraction, or enzyme treatment. This affords the possibility of selective processing to enhance or develop given functional properties. Texturization by extrusion or spinning into fibers are examples of selective processing to obtain a desired property. A better understanding of the physical and chemical properties of soybean proteins in the future will undoubtedly assist in making available a greater number of protein ingredients to cover a broad spectrum of functional properties.

Nutritional Properties

Nutritional properties of soybean proteins are less important than functional properties when the proteins are used solely to provide functionality, because in many such applications the level of protein employed is low. However, when the level of protein involved is a significant part of the diet, nutrition must receive more attention. Soybean proteins have a lower nutritional value than casein, primarily because methionine and cystine content are low. This deficiency can be corrected either by adding methionine or by blending soybean proteins with other proteins. Methionine fortification is used with infant formulas based on soybean protein isolates that are the major source of protein in the diet. Blending soybean protein with other proteins is done successfully with meat analogs. One product, for example, contains soybean, wheat, yeast, and egg protein and has a nutritional value nearly the same as that of casein. Blending proteins is also done in some high-protein breakfast cereals. Although nutrition is a factor to consider, it is not an insurmountable obstacle for soybean proteins in many applications. Because soybean proteins are used primarily as food ingredients and are often blended with other proteins, nutritional considerations of protein quality will mainly concern food processors rather than consumers.

Government Regulations

Composition of a large number of foods in the United States is regulated by standards of identity established under the Federal Food, Drug, and Cosmetic Act and enforced by the Food and Drug Administration. These standards limit or even exclude protein ingredients from a number of foods. For example, the standards for bread permit 0.5 percent of enzyme-active ground soybeans for bleaching purposes, plus an additional 3 percent of soy flour. In contrast, the standards for fruit juices exclude optional protein ingredients.

Composition of meat and poultry products is regulated by the Federal Meat and Poultry Inspection Program of USDA. Standards of identity or composition spell out the amounts and kinds of protein ingredients that may be used in processed meats. For example, it is permissible to add up to 3½ percent of soy flour or soy protein concentrate but only 2

percent of protein isolate to cooked sausages. Nonetheless, these regulations are subject to change. Soy flour has been permitted in sausages for more than 40 years; concentrates were approved as additives in 1962, whereas isolates were allowed in 1964. Currently under consideration are regulations on the use of textured vegetable proteins in meat products (Mussman, 1974).

Although Government regulations may sometimes limit use of soybean proteins, they may also help to stimulate the development of markets. An example of the latter type is the approval in 1971 of textured vegetable proteins for use in the School Lunch Program by the Food and Nutrition Service of USDA. This action is responsible for the present size of the market for textured soybean proteins and provided the stimulus for a number of companies to begin manufacture of these new products. Because of greater competition in this field, it is likely that the quality of textured products will improve and that the variety of items available will increase.

Governmental activities in foreign food assistance programs have also had a positive impact on creating future markets for soybean proteins. These programs have resulted in the development of a number of blended foods such as CSM (corn-soy-milk) and WSB (wheat soy blend), which have provided markets for soy flours; perhaps more important, they have also supported extensive nutritional studies with humans that have shown the effectiveness of soy proteins in supplementing cereal proteins (Graham and Baertl, 1974).

Consumer Acceptance

Economics is a strong driving force in the future development of outlets for soybean proteins, but consumer acceptance can be an equally important hurdle that must be cleared for successful market growth. Many factors, such as appearance, flavor, texture, convenience, nutrition, selling price, and cultural background, influence the consumer's decision to buy a particular food. The influence of selling price was shown with beef-soy blends that sold well as long as beef sold \$0.15 to \$0.20 a pound higher than the blends; when the price differential decreased, blend sales also dropped. The drop in sales of beef-soy blends with declining beef prices indicates that consumers consider beef-soy blends less satisfactory than all beef. This judgment may be based on poor flavor or texture in the cooked product or on the belief that all-meat is better nutritionally than the blends. In the latter case, consumer education could be a factor to promote markets for soybean proteins in products where they are readily identified as major ingredients.

On the other hand, consumer acceptance of soybean proteins is of less importance in foods where they are not a major ingredient (providing that they do not affect flavor or texture adversely). The words "soy" or "soybean" rarely are associated with the name of a product (except for items such as soy sauce), and frequently it is only on careful reading of the ingredient list that it becomes apparent that soybean proteins are one of the components. In products such as breakfast bars, high-protein cereals, etc., convenience and nutrition may be stressed instead.

Greater concern with nutrition by the consumer may also be important in increasing markets for soybean protein products. One company presently is promoting the fact that their meat analogs are free of animal fat and cholesterol. These products provide a greater variety of foods for consumers interested in limiting their intake of animal fats and cholesterol. Increased sales of margarine and lowfat milks in recent years suggest that a sizable portion of the population is exercising some control over their diets.

Advertising can be an important factor in influencing consumer acceptance of soybean protein products. Informative advertising that gives the consumer a clear picture of the advantages and values of such products could have a positive effect on stimulating consumer acceptance and demand. It has been suggested that such an advertising effort be supported and promoted on an industrywide basis rather than by individual companies (Schultz, 1974).

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MARKET POTENTIAL FOR SOY PROTEIN PRODUCTS

By William W. Gallimore
Economic Research Service

The high protein content of soy products is well known, but undesirable flavors, flatus (gas generated in the intestinal system), and problems with color and texture in some uses has limited the growth of its use in edible foods. Although consumer's tastes change slowly, more soy is being used as processing technology improves and other food proteins increase in price.

Actual data are not available on the manufacture of soy products, except edible flour and grits for 1973 and 1974. Estimates of soy production for selected years are given in table 21. All estimates were derived from contacts with industry, but without the estimator having access to actual production figures. Estimated production of flour and grits nearly doubled from 1967 to 1973; however, because industrial flour production was included for 1970, it is impossible to discuss changes in edible flour production from 1967 to 1970 or 1970 to 1973. Production of concentrates increased during the period, with the greater increase from 1970 to 1973. Production of isolates appears to have remained stable during 1967–73. No estimates are given of the production of textured products in 1967. Production of about 30 million pounds in 1970 more than tripled by 1973, making textured products the fastest growing of all products.

Table 21—Estimated U.S. manufacture of soy products, 1967, 1970, and 1973[1]

Soy protein food	1967	1970	1973
	Million pounds		
Flour and grits	305-371	[2] 500-600	[3] 575
Concentrates	17-30	35	50
Isolates	22-35	20-25	20-25
Textured items (extruded and spun)	......	30	100

[1] Source for 1967, Food Uses of Soy Protein, by Cleveland P. Eley, U.S. Dept. Agr., Econ. Res. Serv., ERS-388, Aug. 1968. Source for 1970, Substitutes and Synthetics for Agricultural Products, Projections for 1980, by William Gallimore, U.S. Dept. Agr., Mktg. Res. Rpt. 947, Mar. 1972. Source for 1973, Industry sources, Aug. 1974.
[2] Estimates of flour and grits for 1970 includes flour for industrial use, including pet foods in addition to flour used for edible purposes.
[3] Estimate of edible flour only.

Quarterly production of edible soy flour for the 1973 and 1974 crop years is shown in table 22. These data show a sizable increase in edible flour production, starting with the first quarter of 1974 and reaching more than 168 million pounds the second quarter of 1974, and then dropping slightly in the third quarter. This period generally coincided with high beef prices and the introduction of the soy-beef blends in grocery stores. As beef prices decreased, sale of the soy-beef blends declined and probably accounted, in part, for the decline of edible flour production in the third quarter of 1974. Fourth quarter production in 1974 was the same as the fourth quarter of 1973. The decrease in the fourth quarter for

Table 22—Production of edible soy flour, 1973/74 crop year deliveries[1]

Year and type of flour	Quarters 1	2	3	4	Total for year
	1,000 pounds				
1973:					
Total edible[2]	135,666	135,315	142,440	127,197	540,618
Total industrial[2]	73,360	75,404	68,646	65,570	282,980
Total deliveries[2]	209,026	210,719	211,086	192,767	823,598
1974:					
Total edible[2]	152,088	168,319	149,197	126,883	596,487
Total industrial[2]	82,546	79,684	64,306	64,185	290,721
Total deliveries[2]	234,634	248,003	213,503	191,068	887,208

[1] Data supplied by the Food Protein Council, Washington, D. C. First quarter of the crop year is October, November, and December of the previous calendar year.
[2] Includes exports.

both years probably reflects the drop in demand during the summer months when schools are closed. Edible soy flour production in the 1973–74 crop year accounted for about 3.0 percent of total domestic meal output.

Soy Proteins as Meat Substitutes

Soy proteins have been highly publicized as meat substitutes. The press features new products and many producers of soy products may have felt the demand for soy proteins unlimited. The market for soy proteins has grown and potential for growth still exists; however, demand is not unlimited and growth depends on the relative price of soy and meat products, quality of soy products, changes in State and Federal labeling regulations, and rapidity of change in consumer tastes. At present, we do not know the effect of most factors influencing use of edible soy proteins but there is fragmented information on the acceptance of some soy products.

A low, medium, and high level of market penetration of soy products for red meats was established for 1980 (Gallimore). Growth of substitutes was anticipated mainly in processed meats, with estimates of market penetration reflecting a sum of different rates of substitution for individual products, depending on each product and its market. Soy is likely to be substituted in products that are highly seasoned and use a variety of meats; also, soy proteins are combined with meat and nonmeat products or a product such as ground beef that may be used by consumers in conjunction with other foods or ingredients.

The medium estimate was that 16 percent of projected consumption of processed meat in 1980 would be replaced by soy proteins. This would represent more than 6 percent of red meat production and would require about 1,100 million pounds of soy flour. This is almost double the total production of 596 million pounds of edible soy flour produced in crop year 1974. Unless there is a dramatic increase in the use of soy extenders, it is unlikely this medium projection of market penetration by meat substitutes will be achieved in the next 5 years.

Institutional Markets.—Institutions buy more soy products than individual consumers do and they will probably continue as the major market for soy proteins for some time. The School Lunch Program; State and Federal institutions, such as hospitals and prisons; and to a lesser extent, colleges and other private institutions have used soy meat extenders and meat analogs. Institutions with fixed operational budgets and under pressure of rising costs have made the most extensive use of soy proteins. The lower cost of soy proteins has been largely responsible for the increased substitution of soy products for meat.

Institutions generally combine soy proteins with ground beef, although simulated chicken and beef chunks substitute as complete meats in some menus. Public restaurants, including fast food outlets, use limited quantities of soy in combination with other meats. Fast food outlets will probably be a faster growing market for soy products than conventional restaurants.

Collectively, schools participating in the Federal School Lunch Program are probably the largest domestic market for soy products. In 1971, USDA's Food and Nutrition Service released a special specification making hydrated vegetable protein allowable for reimbursement as a meat alternate. In the current program, textured soy proteins may be mixed with meat, poultry, or fish up to a maximum of 30 percent hydrated soy protein. The following estimates are for vegetable protein (mostly soy) sold to schools (Bird):

School Year	*Million Pounds Dry Weight*
1971–72	9
1972–73	19
1973–74	24

These are only estimates, but schools have made vegetable proteins a major food source in their feeding program. In October 1974, 35 companies produced or distributed textured products meeting requirements for inclusion in the School Lunch Program. Fourteen firms produced or distributed acceptable textured protein product mixes for sloppy joes, meatloaf, taco filling, spaghetti sauce, chili, meat-

balls, pizza, patties, and other products. The School Lunch Program will probably continue as the major user of soy proteins, primarily because of the need to keep cost low and cost savings can be achieved by substituting soy for animal proteins.

Mass Consumer Markets.—Until the past 3 or 4 years, meat substitutes had not been developed for the mass consumer market. With few exceptions, development and sales had been aimed at specially motivated groups, such as vegetarians or people desiring to restrict their intake of animal fats. Even now, meat analogs currently under development or in distribution will probably find their initial acceptance in these specifically motivated groups.

Products intended as extenders for meat, fish, and poultry have the greatest sales potential. Many products currently supplying the institutional market would be packaged for retail sale if there was sufficient demand. However, products are being developed specifically for sale through retail stores to consumers.

Soy-beef blends introduced in grocery stores in March 1973 have already achieved considerable success and have demonstrated the sales potential for soy products under certain conditions. These blends were 25-percent rehydrated soy and 75-percent ground beef and were premixed, packaged, handled, and displayed by the stores in the same manner as ground beef. High ground beef prices preceded the introduction of these blends, creating a favorable climate for their sales. Sales of the blends were observed in three grocery chains for a 46-week period beginning in May 1973 and ending in March 1974. Blend market shares expressed as a percent of total ground beef sales are shown in figure 14. Monthly market share for the blends generally declined from about 28 to just above 20 percent during the 36-week period. The blends averaged 19 cents per pound less than regular ground beef for the period. These data show consumers will buy a soy-extended product if the quality is acceptable and price sufficiently lower than the competing meat product. Total blend sales were estimated at 175 million pounds from July 1973 to June 1974—equivalent to about 15 million pounds of soy products, dry weight.

The first blends were mixed in central plants owned by the store or at the individual stores and not frozen. Currently, blends on the market are packed by independent meat packers and sold frozen in patties or packs.

Success of the premixed soy-beef blends spawned introduction in grocery stores of a number of dry soy products designed for home mixing by consumers. These products ranged from uncolored, unflavored soy products to preseasoned mixes for meatloaf, pizza, meatballs, and other products. Data are not available on quantities sold, but trade publications indicate they met with only limited success. Casserole-type dishes containing soy products are available in grocery stores and offer potential for expanding sale of soy proteins to consumers.

Soy Proteins As Dairy Substitutes

Substitutes such as margarine and whipped toppings have captured much of the butter and light cream markets. Filled and synthetic milks achieved limited success in replacing fluid milk in selected markets in the late 1960's, so substitutes are not new to the dairy industry. Potential for substituting soy proteins exists in three classes of products: nonfat dry milk, fluid milk, and cheese analogs or extenders.

Nonfat dry milk replacers offer growth potential for soy proteins in dairy substitutes. The average wholesale price of nonfat dry milk was 33 cents per pound in September 1972, compared with 57 cents in September 1974. In 1973, demand by food processors for nonfat dry milk was such that prices increased above previous levels and import quotas were changed in 1973 to allow imports of nonfat dry milk. But imports were not available until late 1973 and early 1974.

Wholesale prices increased from 39 cents per pound in January 1973 to 54 cents per pound in January 1974 and then to 67 cents in April 1974. Since June 1974, prices have held at just above the support level of 57 cents per pound. Through October 1974, the Government purchased about 196 million pounds of nonfat dry milk through Commodity Credit

Corporation and as of October, held 135 million pounds in uncommitted inventories. Present demand suggests food processors and other users turned to whey, whey-soy mixtures, or whey mixed with other proteins as replacers for nonfat dry milk during the rapid rise in prices during 1973 and 1974. The exports arrived after the support price had been increased due to rising costs so that supply exceeds the demand at current support levels. The experience of the citrus and cotton textile industries in losing markets indicates that the dairy industry may have difficulty in recapturing markets for nonfat dry milk that have been lost to nonfat milk replacers. In fact, substitutes may gain an increased share of the nonfat milk market.

A number of cheese substitutes are on the market and new ones are currently being developed. These are intended primarily as replacements for cheese in pizza and other cooked dishes. They may be used alone or in conjunction with natural cheese.

Cheese substitutes have received approval for use in the Federal School Lunch Program. They may be used as a cheese alternate, but must be mixed in equal proportions with natural cheese and are permitted only in cooked products. The cheese substitutes must have the same nutritional qualities as natural cheese for acceptance in the program.

It is too early to forecast the demand for soy protein in this market. Some imitation cheeses have no soy protein in their formulations. The total market for imitation cheeses is expected to grow and undoubtedly soy products will form part of the ingredients used.

Soy Proteins in Baked Goods

Baked goods have been a steady and increasing market for soy products, especially flour. Eley estimated that about 50 million pounds of soy flour was used in baked goods in 1967 and estimated industry growth at 5 to 10 percent annually. One private source estimated that slightly more than 100 million pounds of soy flour was used in baked goods in 1973, indicating a growth rate of more than 10 percent. Yet, soy flour can have an adverse effect on baking qualities of bread and other baked goods if not properly processed and treated. New technology has eliminated many of these adverse effects and soy flour and other soy products may gain wider acceptance in the baking industry, not only for these functional qualities but also because they improve nutrition.

Soy Proteins in Foreign Feeding Programs

Soy flour composes part of many commodities such as soy fortified bulgur, soy fortified bread flour, corn-soy milk, corn-soy blend, and wheat-soy blend used in the foreign feeding programs. Soy specifically supplies protein fortification to improve nutrition of the foods. It is estimated that about 644 million pounds of products containing soy flour were distributed under P.L. 480, Title II, in fiscal 1974, representing about 135 million pounds of soy flour, one of the major uses of edible soy flour in the world (Crowley). Corn soy blend, the major use, took an estimated 44 million pounds of soy flour in fiscal 1974.

Low cost, good nutrition, and functional versatility account for the ever-increasing quantities of soy proteins in food programs in less developed countries. Soy flour is the major ingredient in blended foods with flour and grits added to corn, sorghum, and oat products distributed overseas. Whey-soy drink mix is a new product recently added to the list of commodities available for distribution in feeding programs. It was developed as a replacement for dry milk in the feeding program when the price of dry milk increased dramatically in 1973. The finished product, 41.4 percent sweet whey, 36.5 percent full fat soybean flour, 12.1 percent soybean oil, and 9.5 percent corn sugar when mixed with water at 15 percent solids provides a drink with nearly the same energy and protein content as whole milk. Considering present and projected needs, increased quantities of soy proteins will be needed to supply feeding programs under P.L. 480, Title II.

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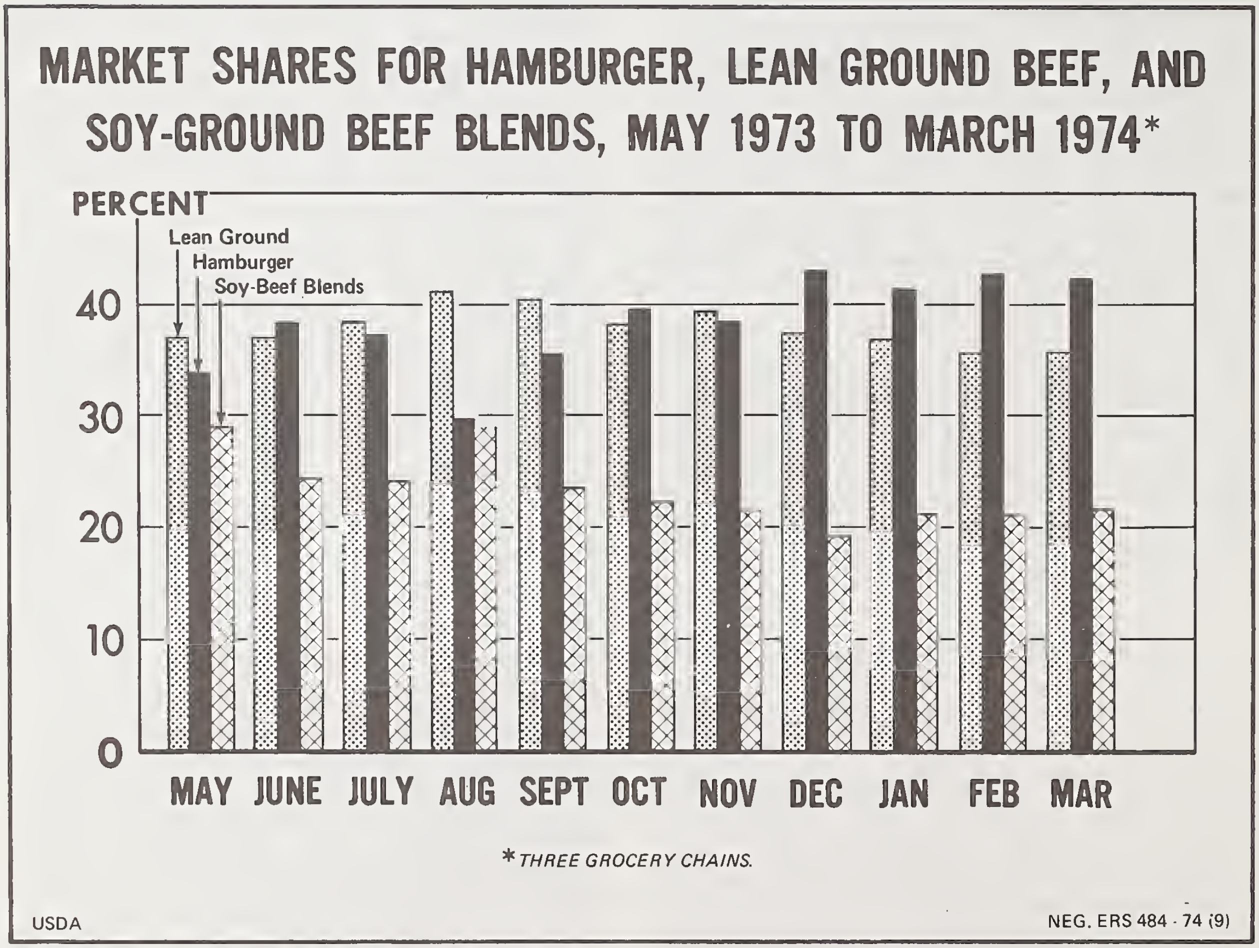
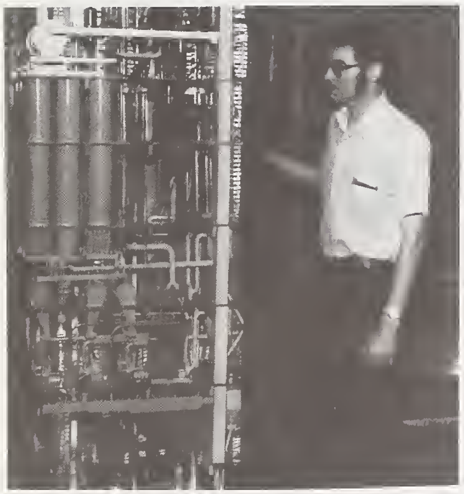


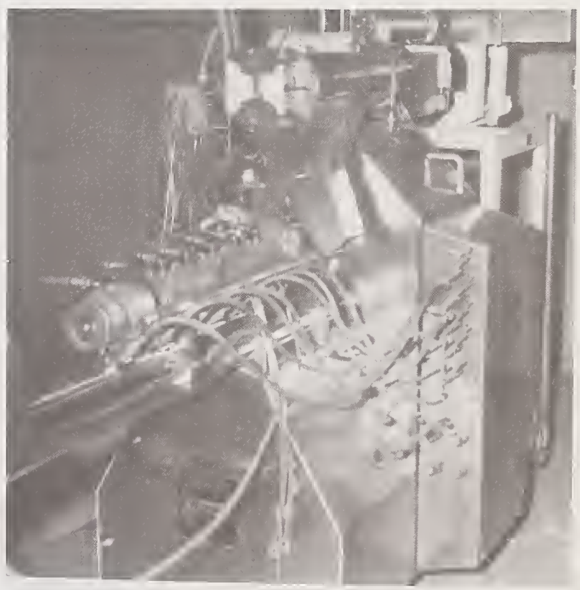
Figure 14. — Comparison of hamburger, lean ground beef and soy-ground beef blends.



David Hammond, soy specialities superintendent, studies soy speciality plant model used for planning and construction of Dawson Mills plant, below.

Owen Olesen, bacteriologist, runs a test in the Dawson Mills laboratory, while chemist Nancy Boese performs protein testing. Owen Olesen works with fiber analysis equipment. Chemists Steve Owen and Tim Maus are engaged in product development experiments.

Pilot size extruder located in laboratory.



APPENDIX — COMPANIES PRODUCING AND DISTRIBUTING SOY PRODUCTS

UNITED STATES DEPARTMENT OF AGRICULTURE
FOOD AND NUTRITION SERVICE

WASHINGTON, D.C. 20250

THIS LISTING IS EFFECTIVE ONLY UNTIL THE NEW REGULATIONS GOVERNING A REFORMULATED TEXTURED VEGETABLE PROTEIN PRODUCT ARE FINALIZED AND PUT INTO EFFECT, AND UNTIL A LISTING OF THE NEW REFORMULATED PRODUCTS IS ISSUED.

September 1974
(6th Revision)

I. Companies Producing and/or Distributing Under Private Label Brands of Textured Vegetable Protein Products that Meet the Requirements of FNS Notice 219

Note: The textured vegetable protein products listed on the following pages may be "textured vegetable proteins," 1/ "concentrates," "isolates" or mixtures. "Textured vegetable proteins" contain from 50 to 55 percent protein on a dry basis. "Concentrates" contain about 70 percent protein. "Isolates" contain from about 90 to 94 percent protein. The mixtures can range from 50 to 70 percent protein. All products are either dry or hydrated. The hydrated products are identified on the list. All others are dry products.

COMPANY	PRODUCT	COLOR	FLAVOR
Allen Foods, Inc. 8543 Page Avenue St. Louis, Missouri 63114	LASCO Fortified, Unflavored Textured Vegetable Protein, 2105 Extender for Beef (identical to NUTRA-MATE 2105 manufactured by A.E. Staley)	dark	unflavored
	LASCO Fortified, Unflavored Textured Vegetable Protein, 2100 Extender for Fish and Poultry (identical to NUTRA-MATE 2100 manufactured by A. E. Staley)	light	unflavored
Archer Daniels Midland Company Box 1470 Decatur, Illinois 62525	TVP Textured Vegetable Protein, unflavored, shredded, fortified	natural	unflavored

1/ Although we use the term "textured vegetable protein products" as a general term to describe all four groups of products, the industry commonly uses this term to describe products containing 50 to 55 percent protein.

COMPANY	PRODUCT	COLOR	FLAVOR
Archer Daniels Midland Company (continued)	TVP Textured Vegetable Protein, unflavored, color C, shredded, fortified	caramel	unflavored
	TVP Textured Vegetable Protein, unflavored, minced 180, fortified	natural	unflavored
	TVP Textured Vegetable Protein, unflavored, color C, minced 180, fortified	caramel	unflavored
	TVP Textured Vegetable Protein, flavor like beef, minced 240, fortified	caramel	beef
	TVP Textured Vegetable Protein, flavor like ham, minced 240, fortified	colored	ham
	TVP Textured Vegetable Protein, unflavored, chunks #10, fortified	natural	unflavored
	TVP Textured Vegetable Protein, flavor like beef, chunks #10, fortified	caramel	beef
	TVP Textured Vegetable Protein, flavor like ham, chunks #10, fortified	colored	ham
Biggers Brothers, Inc. P. O. Box 2356 2800 South Boulevard Charlotte, North Carolina 28201	FARMBEST PROMATE 100 SL Textured Vegetable Protein (identical to PROMATE 100 SL manufactured by Griffith)	caramel	unflavored
	FARMBEST PROMATE 111 SL Textured Vegetable Protein (identical to PROMATE 111 SL manufactured by Griffith)	uncolored	unflavored
Cargill, Incorporated Soy Protein Products Dept. Cargill Building Minneapolis, MN 55402	TEXTRATEIN Minced #18F	uncolored	unflavored
	TEXTRATEIN Minced #18BF	caramel	unflavored
	TEXTRATEIN Minced #50F	uncolored	unflavored
	TEXTRATEIN Minced #50BF	caramel	unflavored
	TEXTRATEIN #12 Chunk F	uncolored	unflavored
	TEXTRATEIN #12 Chunk BF	caramel	unflavored

COMPANY	PRODUCT	COLOR	FLAVOR
Central Soya Company, Inc. 1825 North Laramie Chicago, Illinois 60639	PROMOSOY-SL Soy Protein Concentrate Granular	natural tan	unflavored
	CENTEX - 300 SL Textured Soy Flour	natural tan	unflavored
	CENTEX - 400 SL Textured Soy Flour	caramel	unflavored
	CENTEX - 500 SL Textured Soy Flour	natural tan	unflavored
	CENTEX - 600 SL Textured Soy Flour	caramel	unflavored
Continental Coffee Company 2550 North Clybourn Avenue Chicago, Illinois 60614	CONTINENTAL Fortified, Unflavored Textured Vegetable Protein, Extender for Beef (identical to NUTRA-MATE 2105 manufactured by A. E. Staley)	dark	unflavored
	CONTINENTAL Fortified, Unflavored Textured Vegetable Protein, Extender for Fish and Poultry (identical to NUTRA-MATE 2100 manufactured by A. E. Staley)	light	unflavored
Continental Organization of Distributor Enterprises, Inc. Suite 602 Manor Oak Two 1910 Cochran Road Pittsburgh, Pennsylvania 15220	CODE Fortified, Unflavored Textured Vegetable Protein, 2105 Extender for Beef (identical to NUTRA-MATE 2105 manufactured by A. E. Staley)	dark	unflavored
	CODE Fortified, Unflavored Textured Vegetable Protein, 2100 Extender for Fish and Poultry (identical to NUTRA-MATE 2100 manufactured by A.E. Staley)	light	unflavored
	CODE PROMATE 100 SL Textured Vegetable Protein (identical to PROMATE 100 SL manufactured by Griffith)	caramel	unflavored
	CODE PROMATE 111 SL Textured Vegetable Protein (identical to PROMATE 111 SL manufactured by Griffith)	uncolored	unflavored

September 1974
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COMPANY	PRODUCT	COLOR	FLAVOR
Embassy Grocery Corporation 57-10 49th Street Maspeth, New York 11378	EMBASSY's LUCKY BOY PRO-TENDA, 2105 Textured Vegetable Protein, Fortified (identical to NUTRA-MATE 2105 manufactured by A. E. Staley)	dark	unflavored
	EMBASSY's LUCKY BOY PRO-TENDA, 2100 Textured Vegetable Protein, Fortified (identical to NUTRA-MATE 2100 manufactured by A.E. Staley)	light	unflavored
Far-Mar-Co., Inc. 960 North Halstead Hutchinson, Kansas 67501	ULTRA-SOY Chunks #1, neutral (F)	neutral	unflavored
	ULTRA-SOY Chunks #1, caramel colored (F)	caramel	unflavored
	ULTRA-SOY Chiplets, neutral (F)	neutral	unflavored
	ULTRA-SOY Chiplets, caramel colored (F)	caramel	unflavored
	ULTRA-SOY 100's, neutral (F)	neutral	unflavored
	ULTRA-SOY 100's, caramel colored (F)	caramel	unflavored
	ULTRA-SOY 200's, neutral (F)	neutral	unflavored
	ULTRA-SOY 200's, caramel colored (F)	caramel	unflavored
	ULTRA-SOY Minced, neutral (F)	neutral	unflavored
	ULTRA-SOY Minced, caramel colored (F)	caramel	unflavored
	ULTRA-SOY Chunks #10, neutral (F)	neutral	unflavored
	ULTRA-SOY Chunks #10, caramel colored (F)	caramel	unflavored
	ULTRA-SOY Chunks #20, neutral (F)	neutral	unflavored
	ULTRA-SOY Chunks #20, caramel colored (F)	caramel	unflavored
Federated Foods, Inc. 2250 East Devon Avenue Des Plaines, Illinois 60018	PARADE PROMATE 100 SL Textured Vegetable Protein (identical to PROMATE 100 SL manufactured by Griffith)	caramel	unflavored
	PARADE PROMATE 111 SL Textured Vegetable Protein (identical to PROMATE 111 SL manufactured by Griffith)	uncolored	unflavored
	RED & WHITE PROMATE 100 SL Textured Vegetable Protein (identical to PROMATE 100 SL manufactured by Griffith)	caramel	unflavored

COMPANY	PRODUCT	COLOR	FLAVOR
Federated Foods, Inc. (continued)	RED & WHITE PROMATE 111 SL Textured Vegetable Protein (identical to PROMATE 111 SL manufactured by Griffith)	uncolored	unflavored
First Spice Mixing Co., Inc. 33-33 Greenpoint Avenue Long Island City, N. Y. 11101	TEXITE 176 Textured Vegetable Protein Fortified (identical to TVP Textured Vegetable Protein, minced 180, fortified, manufactured by Archer Daniels Midland)	natural	unflavored
Frozen Food Forum, Inc. 120 W. Wieuca Road Atlanta, Georgia 30342	FROSTY ACRES 2105 Extender for Beef, Fortified Textured Vegetable Protein (identical to NUTRA-MATE 2105 manufactured by A. E. Staley)	dark	unflavored
	FROSTY ACRES 2100 Extender for Fish and Poultry, Fortified Textured Vegetable Protein (identical to NUTRA-MATE 2100 manufactured by A. E. Staley)	light	unflavored
Galanides, Inc. P. O. Box 168 1249 Wicker Drive Raleigh, North Carolina 27604	GALANIDES 2105 Textured Vegetable Protein, Fortified (identical to NUTRA-MATE 2105 manufactured by A. E. Staley)	dark	unflavored
	GALANIDES 2100 Textured Vegetable Protein, Fortified (identical to NUTRA-MATE 2100 manufactured by A. E. Staley)	light	unflavored
General Mills, Inc. 9200 Wayzata Blvd. Minneapolis, Minnesota 55440	<u>Frozen Products</u> (hydrated products)		
	BONTRAE Textured Vegetable Protein Product Crumbles with Flavor Like Beef	caramel	beef
	BONTRAE Textured Vegetable Protein Product Dice with Flavor Like Ham	colored	ham
	BONTRAE Vegetable Protein Product Chunks with Flavor Like Chicken	colored	chicken
	BONTRAE Textured Vegetable Protein Product Dice with Flavor Like Chicken	colored	chicken

COMPANY	PRODUCT	COLOR	FLAVOR
General Mills, Inc. (continued)	Dehydrated Products		
	BONTRAE Textured Vegetable Protein Product Crumbles with Flavor Like Beef	caramel	beef
	BONTRAE Textured Vegetable Protein Product Unflavored Crumbles with Color	caramel	unflavored
	BONTRAE Textured Vegetable Protein Product Unflavored Crumbles	uncolored	unflavored
	GENERAL MILLS Textured Vegetable Protein Product Crumbles with a Flavor Like Beef	caramel	beef
	GENERAL MILLS Textured Vegetable Protein Product Unflavored Crumbles with Color	caramel	unflavored
	GENERAL MILLS Textured Vegetable Protein Product Unflavored Crumbles	uncolored	unflavored
	GENERAL MILLS PROTEIN II Textured Vegetable Protein Flakes	uncolored	flavored
Griffith Laboratories 1415 West 37th Street Chicago, Illinois 60609	GRIFFITH's GL-219 Granular Soy Protein Concentrate	uncolored	unflavored
	GRIFFITH's PROMATE # 100 SL Textured Vegetable Protein	caramel	unflavored
	GRIFFITH's PROMATE # 111 SL Textured Vegetable Protein	uncolored	unflavored
	GRIFFITH's PROMATE # 500 SL Textured Vegetable Protein	caramel	unflavored
	GRIFFITH's PROMATE # 555 SL Textured Vegetable Protein	uncolored	unflavored
	GRIFFITH's GSVP 125 SL Structured Soy Flour	uncolored	unflavored
	GRIFFITH's GSVP 125C SL Structured Soy Flour	caramel	unflavored
	GRIFFITH's GSVP 150 SL Structured Soy Flour	uncolored	unflavored
	GRIFFITH's GSVP 150C SL Structured Soy Flour	caramel	unflavored

COMPANY	PRODUCT	COLOR	FLAVOR
Griffith Laboratories (continued)	GRIFFITH's GSPC 125 SL Textured Soy Protein Concentrate	uncolored	unflavored
	GRIFFITH's GSPC 125C SL Textured Soy Protein Concentrate	caramel	unflavored
	GRIFFITH's GSPC 150 SL Textured Soy Protein Concentrate	uncolored	unflavored
	GRIFFITH's GSPC 150C SL Textured Soy Protein Concentrate	caramel	unflavored
B. Heller & Company Calumet Avenue & 40th Street Chicago, Illinois 60653	HELLER's Textured Vegetable Protein #65 with Vitamin Supplement	neutral	unflavored
	HELLER's Textured Vegetable Protein #75 with Vitamin Supplement	caramel	unflavored
Hollymatic Corporation 80 North Street Park Forrest, Illinois 60466	HOLLYMATIC Soy Protein Concentrate S.P.C. 219 (identical to GL-219 manufactured by Griffith)	neutral	unflavored
Institutional Wholesalers, Inc. P. O. Box 4747 Liberty Church Road at Highway 247 North Macon, GA 31208	SAXONY Textured Vegetable Protein Fortified, Color C, Minced No. 180 (identical to TVP, minced 180, fortified, color C manufactured by Archer Daniels Midland)	caramel	unflavored
	SAXONY Textured Vegetable Protein, Fortified, Minced No. 180 (identical to TVP, minced 180, fortified manufactured by Archer Daniels Midland)	natural	unflavored
	SAXONY Textured Vegetable Protein Fortified, Color C, Minced No. 240, (identical to TVP, minced 240, fortified, color C manufactured by Archer Daniels Midland)	caramel	unflavored
	SAXONY Textured Vegetable Protein, Fortified, Minced No. 240 (identical to TVP, minced 240, fortified manufactured by Archer Daniels Midland)	natural	unflavored

COMPANY	PRODUCT	COLOR	FLAVOR
Lauhoff Grain Company, Inc. 321 East North Street Danville, IL 61832	VITA-PRO 100 or XVP 100	colored	unflavored
	VITA-PRO 111 or XVP 111	uncolored	unflavored
	VITA-PRO 100CS or XVP 100CS	colored	unflavored
	VITA-PRO 555 or XVP 555	uncolored	unflavored
	VITA-PRO 500 or XVP 500	colored	unflavored
Marshall Produce Company Division of Marshall Foods, Inc. Marshall, MN 56258	MARSHALL Textured Vegetable Protein MARTEX, Code 910 (identical to TEXTRATEIN minced #18F manufactured by Cargill)	uncolored	unflavored
	MARSHALL Textured Vegetable Protein MARTEX, Code 915 (identical to TEXTRATEIN minced #18 BF manufactured by Cargill)	caramel	unflavored
Miles Laboratories Elkhart, IN 46514	MILES MAXTEN-C, a Textured Vegetable Protein Product	caramel	unflavored
	MILES MAXTEN-U, a Textured Vegetable Protein Product	uncolored	unflavored
	TEMPTEIN BEEF-LIKE FLAVORED GRANULES, a Spun Vegetable Protein Product	caramel	beef
	TEMPTEIN MEAT-LIKE NUGGETS, an Unflavored Spun Vegetable Protein Product	caramel	unflavored
Nabisco, Inc. Protein Foods Division 425 Park Avenue New York City, NY 10022	VMR I Fortified Textured Vegetable Protein, Size 516	caramel or uncolored	unflavored or flavored
	VMR I Fortified Textured Vegetable Protein, Size 500	caramel or uncolored	unflavored or flavored
	VMR I Fortified Textured Vegetable Protein, Size 816	caramel or uncolored	unflavored or flavored
	VMR I Fortified Textured Vegetable Protein, Size 1600	caramel or uncolored	unflavored or flavored
	VMR II Fortified Textured Vegetable Protein, Size 1418	caramel or uncolored	unflavored or flavored
	VMR II Fortified Textured Vegetable Protein, Size 3814	caramel or uncolored	unflavored or flavored

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COMPANY	PRODUCT	COLOR	FLAVOR
Nabisco, Inc. (continued)	VMR III Fortified Textured Vegetable Protein, Coarse	caramel or uncolored	unflavored or flavored
	VMR III Fortified Textured Vegetable Protein, Size 600	caramel or uncolored	unflavored or flavored
National Institutional Food Distributor Associates, Inc. Box 19936, Station N Atlanta, GA 30325	NIFDA PROMATE 100SL Textured Vegetable Protein (identical to PROMATE 100SL manufactured by Griffith)	caramel	unflavored
	NIFDA PROMATE 111SL Textured Vegetable Protein (identical to PROMATE 111SL manufactured by Griffith)	uncolored	unflavored
National Protein Corporation 4830 S. Christiana Avenue Chicago, IL 60632	TEXTRASOY-412 FC Textured Vegetable Protein	caramel	unflavored
	TEXTRASOY-412 F Textured Vegetable Protein	uncolored	unflavored
National School-Pak 1415 West 37th Street Chicago, IL 60609	NATIONAL SCHOOL-PAK PROMATE 100 SL Textured Vegetable Protein (identical to PROMATE 100 SL manufactured by Griffith)	caramel	unflavored
	NATIONAL SCHOOL-PAK PROMATE 111 SL Textured Vegetable Protein (identical to PROMATE 111 SL manufactured by Griffith)	uncolored	unflavored
Nugget Distributors, Inc. P. O. Box 8309 Stockton, CA 95204	NUGGET PROMATE 100 SL Textured Vegetable Protein (identical to PROMATE 100 SL manufactured by Griffith)	caramel	unflavored
	NUGGET PROMATE 111 SL Textured Vegetable Protein (identical to PROMATE 111 SL manufactured by Griffith)	uncolored	unflavored
	NUGGET MAGI-PRO Fortified, Unflavored Textured Vegetable Protein, 2105 (identical to NUTRA-MATE 2105 manufactured by A. E. Staley)	dark	unflavored
	NUGGET MAGI-PRO Fortified, Unflavored Textured Vegetable Protein, 2100 (identical to NUTRA-MATE 2100 manufactured by A. E. Staley)	light	unflavored

COMPANY	PRODUCT	COLOR	FLAVOR
Oppenheimer Casing Co. 1020 West 36th St. Chicago, Illinois 60609	TEXTURED OPPENHEIMER PRO 110 Textured Vegetable Protein (identical to MIRA-TEX 210-F manufactured by A. E. Staley)	uncolored	unflavored
	TEXTURED OPPENHEIMER PRO 110-C Textured Vegetable Protein (identical to MIRA-TEX 210-2-F manufactured by A. E. Staley)	caramel	unflavored
Portland Wholesale Grocery Co. 3939 S.E. 26th Avenue Portland, Oregon 97207	PREFERRED STOCK Fortified, Unflavored Textured Vegetable Protein, Extender for Beef 2105 (identical to NUTRA-MATE 2105 manufactured by A. E. Staley)	dark	unflavored
	PREFERRED STOCK Fortified, Unflavored Textured Vegetable Protein, Extender for Poultry and Seafood 2100 (identical to NUTRA-MATE 2100 manufactured by A. E. Staley)	light	unflavored
Ralcon Foods 2 North Riverside Plaza Chicago, Illinois 60606	SPF-200-Fortified (hydrated product)	natural	unflavored
Ralston Purina Company Checkerboard Square St. Louis, Missouri 63188	SUPRO 50A-1F Textured Vegetable Protein	caramel	unflavored
	SUPRO 50A-2F Textured Vegetable Protein	uncolored	unflavored
	SUPRO 50A-3F Textured Vegetable Protein	caramel	unflavored
	SUPRO 50A-4F Textured Vegetable Protein	uncolored	unflavored
	SUPRO 50-1F Textured Vegetable Protein	caramel	unflavored
	SUPRO 50-2F Textured Vegetable Protein	uncolored	unflavored
	SUPRO 50-3F Textured Vegetable Protein	caramel	unflavored
	SUPRO 50-4F Textured Vegetable Protein	uncolored	unflavored
S. E. Rykoff & Company 761 Terminal Street Los Angeles, CA 90021	S.E.R. Unflavored, Fortified PRO-TEAM Caramel Colored Textured Vegetable Protein, 2105 Extender for Beef (identical to NUTRA-MATE 2105 manufactured by A. E. Staley)	caramel	unflavored

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COMPANY	PRODUCT	COLOR	FLAVOR
S. E. Rykoff & Company (continued)	S.E.R. Unflavored, Fortified PRO-TEAM White Textured Vegetable Protein, 2100 Extender for Fish and Poultry (identical to NUTRA-MATE 2100 manufactured by A. E. Staley)	white	unflavored
	S.E.R. Unflavored, Caramel Colored, Fortified PRO-TEAM Textured Vegetable Protein, minced 180 (identical to TVP, minced 180, fortified, color C manufactured by Archer Daniels Midland)	caramel	unflavored
	S.E.R. Unflavored, White, Fortified PRO-TEAM Textured Vegetable Protein, minced 180 (identical to TVP, minced 180, fortified manufactured by Archer Daniels Midland)	white	unflavored
John Sexton & Company P. O. Box JS Chicago, Illinois 60690	SEXTON PROTEIN-PLUS Textured Vegetable Protein	caramel	unflavored
	SEXTON PROTEIN-PLUS FLAKES Textured Vegetable Protein	uncolored	unflavored
A. E. Staley Mfg. Company Food Service Division 2011 Swift Drive Oak Brook, Illinois 60521	NUTRA-MATE Fortified, Unflavored Textured Vegetable Protein 2100	light	unflavored
	NUTRA-MATE Fortified, Unflavored Textured Vegetable Protein 2105	dark	unflavored
	NUTRA-MATE Fortified, Unflavored Textured Vegetable Protein 2410F	light	unflavored
A. E. Staley Mfg. Company Protein Division 2200 Eldorado Street Decatur, Illinois 62525	MIRA-TEX 200-F Textured Vegetable Protein	uncolored	unflavored
	MIRA-TEX 200-F (2H) Textured Vegetable Protein	uncolored	flavored
	MIRA-TEX 210-F Textured Vegetable Protein	uncolored	unflavored
	MIRA-TEX 210-F (2) Textured Vegetable Protein	uncolored	unflavored
	MIRA-TEX 210-1-F Textured Vegetable Protein	caramel	unflavored
	MIRA-TEX 210-1-F (2) Textured Vegetable Protein	caramel	unflavored
	MIRA-TEX 210-2-F Textured Vegetable Protein	caramel	unflavored
	MIRA-TEX 220-F Textured Vegetable Protein	uncolored	unflavored

COMPANY	PRODUCT	COLOR	FLAVOR
A. E. Staley Mfg. Co. Protein Division (continued)	MIRA-TEX 220-1-F Textured Vegetable Protein	caramel	unflavored
	MIRA-TEX 220-2-F Textured Vegetable Protein	caramel	unflavored
	MIRA-TEX 230-F Textured Vegetable Protein	uncolored	unflavored
	MIRA-TEX 230-1-F Textured Vegetable Protein	caramel	unflavored
	MIRA-TEX 230-2-F Textured Vegetable Protein	caramel	unflavored
	MIRA-TEX 240-F Textured Vegetable Protein	uncolored	unflavored
	MIRA-TEX 400-F Textured Vegetable Protein	uncolored	unflavored
	MIRA-TEX 400-11-F Textured Vegetable Protein	caramel	unflavored
	MIRA-TEX 405-F Textured Vegetable Protein	uncolored	unflavored
	MIRA-TEX 405-F(2) Textured Vegetable Protein	uncolored	unflavored
	MIRA-TEX 405-11-F Textured Vegetable Protein	caramel	unflavored
	MIRA-TEX 410-F Textured Vegetable Protein	uncolored	unflavored
	MIRA-TEX 410-11-F Textured Vegetable Protein	caramel	unflavored
Swift Edible Oil Company 115 West Jackson Boulevard Chicago, Illinois 60604	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:10000 TA	uncolored	unflavored
	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:10100 TA	uncolored	unflavored
	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:10107 TA	uncolored	flavored
	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:10300 TA	uncolored	unflavored
	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:10307 TA	uncolored	flavored
	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:10407 TA	uncolored	flavored
	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:10900 TA	uncolored	unflavored

COMPANY	PRODUCT	COLOR	FLAVOR
Swift Edible Oil Company (continued)	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:10907 TA	uncolored	flavored
	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:52000 TA	caramel	unflavored
	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:52000-D TA	caramel	unflavored
	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:52300 TA	caramel	unflavored
	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:52400 TA	caramel	unflavored
	SWIFT's SFP-TA	uncolored	unflavored
	SWIFT's BURGER-AIDE I	uncolored	beef
Sysco Corporation Capital National Bank Bldg. 1300 Main Street, Suite 800 Houston, Texas 77002	SYSCO Fortified, Unflavored Textured Vegetable Protein for Use with Fish and Poultry, 2100 (identical to NUTRA-MATE 2100 manufactured by A. E. Staley)	light	unflavored
	SYSCO PROMATE 100SL Textured Vegetable Protein (identical to PROMATE 100SL manufactured by Griffith)	caramel	unflavored
	SYSCO PROMATE 111SL Textured Vegetable Protein (identical to PROMATE 111SL manufactured by Griffith)	uncolored	unflavored
	SYSCO Fortified, Unflavored Textured Vegetable Protein for Use with Meat, 2105 (identical to NUTRA-MATE 2105 manufactured by A. E. Staley)	dark	unflavored

Since the September 1974 listing of acceptable textured vegetable protein products (6th revision) was released, we have examined analyses of the following textured vegetable protein products and find them acceptable under FNS Notice 219 for use in the Child Nutrition Programs.

COMPANY	PRODUCT	COLOR	FLAVOR
Custom Food Products, Inc. 3127 W. Chicago Avenue Chicago, IL 60622	CFP Textured Vegetable Protein, Coarse, Plain (identical to VITA-PRO 555 manufactured by Lauhoff Grain Company)	Uncolored	Unflavored
	CFP Textured Vegetable Protein, Coarse, Colored (identical to VITA-PRO 500 manufactured by Lauhoff Grain Company)	Colored	Unflavored
	CFP Textured Vegetable Protein, Medium, Plain (identical to VITA-PRO 111 manufactured by Lauhoff Grain Company)	Uncolored	Unflavored
	CFP Textured Vegetable Protein, Medium, Colored (identical to VITA-PRO 100 manufactured by Lauhoff Grain Company)	Colored	Unflavored
Miles Laboratories, Inc. Elkhart, IN 46514	PRO-LEAN-CF, a Textured Vegetable Protein Product	Caramel	Unflavored
	PRO-LEAN-UF, a Textured Vegetable Protein Product	Uncolored	Unflavored
	PRO-LEAN-CF, a Textured Vegetable Protein Product with Spices and Seasonings	Caramel	Flavored
	PRO-LEAN-UF, a Textured Vegetable Protein Product with Spices and Seasonings	Uncolored	Flavored
Ralston Purina Company Checkerboard Square St. Louis, MO 63188	SUPRO 50-5F Textured Vegetable Protein	Caramel	Unflavored
	SUPRO 50-21F Textured Vegetable Protein	Caramel	Unflavored

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COMPANY	PRODUCT	COLOR	FLAVOR
Ralston Purina Company (Continued)	SUPRO 50A-6F Textured Vegetable Protein	Uncolored	Unflavored
Industrial Grain Products, Ltd. P. O. Box 6089 Montreal, Quebec H3C - 3H1 Canada	PERPLUS Code 9924 Textured Soy Flour-Wheat Gluten Blend, fortified	Natural	Unflavored
	PERPLUS Code 9936 Textured Soy Flour-Wheat Gluten Blend, fortified	Caramel	Unflavored
Archer Daniels Midland Co. Box 1470 Decatur, IL 62525	TVP Textured Vegetable Protein, flavor like beef, minced 180, fortified	Caramel	Beef flavor
	TVP Textured Vegetable Protein, unflavored, Color C, minced 240, fortified	Caramel	Unflavored
General Spice, Inc. 238 St. Nicholas Street South Plainfield, NJ 07080	SOTEX Textured Soy Flour F (identical to TVP, minced 180, fortified, manufactured by Archer Daniels Midland)	Uncolored	Unflavored
or 6338 Lambert Street Detroit, MI 48211	SOTEX Textured Soy Flour CF (identical to TVP, minced 180, fortified, Color C manufactured by Archer Daniels Midland)	Caramel	Unflavored
Custom Food Products, Inc. 3127 W. Chicago Avenue Chicago, IL 60622	CFP Textured Vegetable Protein, Medium-Plain 6175 (identical to TEXTRATEIN, Minced 18F, manufactured by Cargill)	Uncolored	Unflavored
	CFP Textured Vegetable Protein, Medium-Colored 6176 (identical to TEXTRATEIN, Minced 18BF, manufactured by Cargill)	Caramel	Unflavored
	CFP Textured Vegetable Protein, Coarse-Plain 6177 (identical to TEXTRATEIN, Minced 50F, manufactured by Cargill)	Uncolored	Unflavored

COMPANY	PRODUCT	COLOR	FLAVOR
Custom Food Products, Inc. (Continued)	CFP Textured Vegetable Protein, Coarse-Colored 6178 (identical to TEXTRATEIN, Minced 50BF, manufactured by Cargill)	Caramel	Unflavored
Cargill, Inc. Soy Protein Products Dept. Cargill Building Minneapolis, MN 55402	TEXTRATEIN, Minced, 11F	Uncolored	Unflavored
	TEXTRATEIN, Minced, 11BF	Caramel	Unflavored
	TEXTRATEIN, Minced, 24F	Uncolored	Unflavored
	TEXTRATEIN, Minced, 24BF	Caramel	Unflavored

II. Companies Producing and/or Distributing Under Private Label Acceptable Textured Vegetable Protein Product Mixes

Note: Textured vegetable protein product "mixes" combine textured vegetable protein with dehydrated vegetables, seasonings, bread crumbs or cereals. Only the textured vegetable protein component in the mix may be credited in the Type A lunch. Column 3 below gives the amount of textured vegetable protein in each mix. Yield information in column 4 is based on directions for use or specific recipes on individual mix product labels. " " indicate names of recipes as they appear on the label. The servings stated specify the number of servings of meat/mix combination equivalent to the specified amount of cooked lean meat that may be credited toward the meat/meat alternate requirement of the Type A lunch. The actual size of serving is larger than the equivalent amount of meat/meat alternate and should be stated on the individual product label.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Alberto-Culver Company 2525 Armitage Avenue Melrose Park, IL 60160	MILANI Base Mix with Textured Vegetable Protein	18.8% or 3-1/4 oz per 18 oz pkg. (net wt.)	"Directions": 49 2-ounce equivalent servings of meat/meat alternate per pkg. "Minuette of Beef": 49 2-ounce equivalent servings of meat/meat alternate per pkg. "DeLuxe Hamburger": 119 2-ounce equivalent servings of meat/meat alternate per pkg. "Economy Meat Loaves": 38 2-ounce equivalent servings of meat/meat alternate per pkg.
	MILANI Sloppy Joe Mix with Textured Vegetable Protein	55.88% or 26-3/4 oz per 48 oz pkg. (net wt.)	82 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the MILANI mixes is MIRA-TEX 240F or MIRA-TEX 210-2-F manufactured by A. E. Staley.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Bernard Food Industries, Inc. 1125 Hartrey Avenue P. O. Box 1497 Evanston, IL 60204	TEX-PRO ONE Meat Extender for Hamburger Patties	83.29% or 30 oz per 36 oz pkg. (net wt.)	"Directions to Yield a 19 lb. Loaf": 99 2-ounce equivalent servings of meat/meat alternate per pkg.
	TEX-PRO TWO for Preparing Meat Loaf	39.67% or 19 oz per 48 oz pkg. (net wt.)	"To Yield a 14 Pound Meat Loaf": 58 2-ounce equivalent servings of meat/meat alternate per pkg.
	TEX-PRO THREE Sloppy Joe Mix	58.4% or 30 oz per 52 oz pkg. (net wt.)	"To Prepare Over 4 Gallons Sloppy Joe Filling": 200 1-ounce equivalent servings of meat/meat alternate per pkg. "To Prepare 3 Gallons Meatless Sloppy Joe Filling" is NOT for School Lunch.
	TEX-PRO FOUR Chili Mix	47.45% or 22-3/4 oz per 48 oz pkg. (net wt.)	"Chili Con Carne with Beans" and "Corn Chip Chili Casserole": 150 2-ounce equivalent servings of meat/meat alternate per pkg. "Chili Mac": 75 2-ounce equivalent servings of meat/meat alternate and 1/4 cup servings of vegetable per pkg. "Deluxe Chili Mac": 100 2-ounce equivalent servings of meat/meat alternate and 1/4 cup servings of vegetable per pkg.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Bernard Food Industries, Inc. (continued)	TEX-PRO FIVE Taco Filling Mix	47.09% or 30 oz per 4 lb pkg. (net wt.)	"Directions to Prepare 25 lbs. Finished Taco Filling": 200 1-ounce equivalent servings of meat/meat alternate and 1/4 cup servings of vegetable per pkg.
			"Taco Dogs": 200 2-ounce equivalent servings of meat/meat alternate and a serving of bread per 1/2 pkg.
	TEX-PRO SIX Veal-Pork-Tuna & Salmon Patty Mix	74.48% or 35-3/4 oz per 48 oz pkg. (net wt.)	"Directions to Yield 232 One (1) Ounce Equivalent Meat/Meat Alternate Patties": 232 1-ounce equivalent servings of meat/meat alternate per pkg.
			"Directions to Yield 160 Half-Cup Servings of Protein-Rich Tuna Salad": 160 2-ounce equivalent servings of meat/meat alternate per 2/3 pkg.
	TEX-PRO SEVEN Spaghetti Sauce Mix	62.5% or 30 oz per 48 oz pkg. (net wt.)	"To Prepare Over 4 Gallons Protein Spaghetti Sauce with Meat": 200 1-ounce equivalent servings of meat/meat alternate per pkg.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Bernard Food Industries, Inc. (continued)	TEX-PRO SEVEN Spaghetti Sauce Mix (continued)		"To Prepare 3 Gallons Meatless Protein Spaghetti Sauce" is NOT for School Lunch.

Note: The textured vegetable protein component of the Bernard mixes is TVP, minced 180, fortified, color C and uncolored manufactured by Archer Daniels Midland, or MIRA-TEX 220-F and 220-1-F manufactured by A. E. Staley.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Biggers Brothers, Inc. P. O. Box 2356 2800 South Boulevard Charlotte, NC 28201	FARMBEST School Lunch Chili Mix & Textured Vegetable Protein	42.06% or 17-3/4 oz per 2 lb 10 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	FARMBEST School Lunch Meat Loaf/Meat Ball Mix & Textured Vegetable Protein	48.93% or 20 oz per 2 lb 9 oz pkg. (net wt.)	84 2-ounce equivalent servings of meat/meat alternate per pkg.
	FARMBEST School Lunch Patty Mix & Textured Vegetable Protein	83.03% or 30-1/4 oz per 2 lb 4-1/2 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	FARMBEST School Lunch Pizza Sauce Mix & Textured Vegetable Protein	55% or 17-1/2 oz per 2 lb pkg. (net wt.)	112 2-ounce equivalent servings of meat/meat alternate per pkg.
	FARMBEST School Lunch Sloppy Joe Mix & Textured Vegetable Protein	52.13% or 28-3/4 oz per 3 lb 7 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	FARMBEST School Lunch Spaghetti Sauce Mix & Textured Vegetable Protein	46.58% or 16-3/4 oz per 2 lb 4 oz pkg. (net wt.)	100 1-ounce equivalent servings of meat/meat alternate per pkg.
	FARMBEST School Lunch Taco Mix & Textured Vegetable Protein	61.82% or 24-3/4 oz per 2 lb 8 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the FARMBEST mixes is GL-219, PROMATE #500-SL or PROMATE #100-SL manufactured by Griffith.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Continental Organization of Distributor Enterprises, Inc. Suite 602 Manor Oak Two 1910 Cochran Road Pittsburgh, PA 15220	CODE School Lunch Chili Mix & Textured Vegetable Protein	42.06% or 17-3/4 oz per 2 lb 10 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	CODE School Lunch Meat Loaf/ Meat Ball Mix & Textured Vegetable Protein	48.93% or 20 oz per 2 lb 9 oz pkg. (net wt.)	84 2-ounce equivalent servings of meat/meat alternate per pkg.
	CODE School Lunch Patty Mix & Textured Vegetable Protein	83.03% or 30-1/4 oz per 2 lb 4-1/2 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	CODE School Lunch Pizza Sauce Mix & Textured Vegetable Protein	55% or 17-1/2 oz per 2 lb pkg. (net wt.)	112 2-ounce equivalent servings of meat/meat alternate per pkg.
	CODE School Lunch Sloppy Joe Mix & Textured Vegetable Protein	52.13% or 28-3/4 oz per 3 lb 7 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	CODE School Lunch Spaghetti Sauce Mix & Textured Vegetable Protein	46.58% or 16-3/4 oz per 2 lb 4 oz pkg. (net wt.)	100 1-ounce equivalent servings of meat/meat alternate per pkg.
	CODE School Lunch Taco Mix & Textured Vegetable Protein	61.82% or 24-3/4 oz per 2 lb 8 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the CODE mixes is GL-219, PROMATE #500-SL or PROMATE #100-SL manufactured by Griffith.

Federated Foods, Inc. 2250 East Devon Avenue Des Plaines, IL 60018	RED & WHITE or PARADE School Lunch Chili Mix & Textured Vegetable Protein	42.06% or 17-3/4 oz per 2 lb 10 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.

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COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Fedcrated Foods, Inc. (continued)	RED & WHITE or PARADE School Lunch Meat Loaf/Meat Ball Mix & Textured Vegetable Protein	48.93% or 20 oz per 2 lb 9 oz pkg. (net wt.)	84 2-ounce equivalent servings of meat/meat alternate per pkg.
	RED & WHITE or PARADE School Lunch Patty Mix & Textured Vegetable Protein	83.03% or 30-1/4 oz per 2 lb 4-1/2 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	RED & WHITE or PARADE School Lunch Pizza Sauce Mix & Textured Vegetable Protein	55% or 17-1/2 oz per 2 lb pkg. (net wt.)	112 2-ounce equivalent servings of meat/meat alternate per pkg.
	RED & WHITE or PARADE School Lunch Sloppy Joe Mix & Textured Vegetable Protein	52.13% or 28-3/4 oz per 3 lb 7 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	RED & WHITE or PARADE School Lunch Spaghetti Sauce Mix & Textured Vegetable Protein	46.58% or 16-3/4 oz per 2 lb 4 oz pkg. (net wt.)	100 1-ounce equivalent servings of meat/meat alternate per pkg.
	RED & WHITE or PARADE School Lunch Taco Mix & Textured Vegetable Protein	61.82% or 24-3/4 oz per 2 lb 8 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the RED & WHITE and PARADE mixes is GL-219, PROMATE #500-SL or PROMATE #100-SL manufactured by Griffith.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Kraft Foods 500 Peshtigo Court Chicago, Illinois 60690	KRAFT School Lunch Chili Mix & Textured Vegetable Protein	42.06% or 17-3/4 oz per 2 lb 10 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	KRAFT School Lunch Sloppy Joe Mix & Textured Vegetable Protein	52.13% or 28-3/4 oz per 3 lb 7 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the KRAFT mixes is PROMATE #500-SL or PROMATE #100-SL manufactured by Griffith.

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COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Lawry's Foods, Inc. 568 San Fernando Road Los Angeles, CA 90065	LAWRY's STRETCH Taco Filling Mix	54.30% or 39 oz per 4-1/2 lb pkg. (net wt.)	76 2-ounce equivalent servings of meat/meat alternate per 1/2 pkg.

Note: The textured vegetable protein component of the LAWRY mix is ULTRA-SOY (F) manufactured by Far-Mar-Co.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Milwaukee Seasoning Laboratories, Inc. 2803 North 32nd Street Milwaukee, WI 53210	MSL TVP PATTY MIX #1118	85% or 17 lb per 20 lb pkg. (net wt.)	1649 2-ounce equivalent servings of meat/meat alternate per pkg.
	FLAVORMATE Complete School Lunch Beef & Patty Mix #1526	85% or 11 lb per 13 lb pkg. (net wt.)	570 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the Milwaukee Seasoning mixes is TEXRATEIN #18F manufactured by Cargill, TVP fortified manufactured by Archer Daniels Midland or BONTRAE unflavored crumbles manufactured by General Mills.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
National Institutional Food Distributor Associates, Inc. P. O. Box 19936, Station N Atlanta, GA 30325	NIFDA School Lunch Chili Mix & Textured Vegetable Protein	42.06% or 17-3/4 oz per 2 lb 10 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	NIFDA School Lunch Meat Loaf/ Meat Ball Mix & Textured Vegetable Protein	48.93% or 20 oz per 2 lb 9 oz pkg. (net wt.)	84 2-ounce equivalent servings of meat/meat alternate per pkg.
	NIFDA School Lunch Patty Mix & Textured Vegetable Protein	83.03% or 30-1/4 oz per 2 lb 4-1/2 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	NIFDA School Lunch Pizza Sauce Mix & Textured Vegetable Protein	55% or 17-1/2 oz per 2 lb pkg. (net wt.)	112 2-ounce equivalent servings of meat/meat alternate per pkg.
	NIFDA School Lunch Sloppy Joe Mix & Textured Vegetable Protein	52.13% or 28-3/4 oz per 3 lb 7 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	NIFDA School Lunch Spaghetti Sauce Mix & Textured Vegetable Protein	46.58% or 16-3/4 oz per 2 lb 4 oz pkg. (net wt.)	100 1-ounce equivalent servings of meat/meat alternate per pkg.
	NIFDA School Lunch Taco Mix & Textured Vegetable Protein	61.82% or 24-3/4 oz per 2 lb 8 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the NIFDA mixes is GL-219, PROMATE #500-SL or PROMATE #100-SL manufactured by Griffith.

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COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
National School-Pak 1415 West 37th Street Chicago, IL 60609	NATIONAL SCHOOL-PAK School Lunch Chili Mix & Textured Vegetable Protein	42.06% or 17-3/4 oz per 2 lb 10 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	NATIONAL SCHOOL-PAK School Lunch Meat Loaf/Meat Ball Mix & Textured Vegetable Protein	48.93% or 20 oz per 2 lb 9 oz pkg. (net wt.)	84 2-ounce equivalent servings of meat/meat alternate per pkg.
	NATIONAL SCHOOL-PAK School Lunch Patty Mix & Textured Vegetable Protein	83.03% or 30-1/4 oz per 2 lb 4-1/2 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	NATIONAL SCHOOL-PAK School Lunch Pizza Sauce Mix & Textured Vegetable Protein	55% or 17-1/2 oz per 2 lb pkg. (net wt.)	112 2-ounce equivalent servings of meat/meat alternate per pkg.
	NATIONAL SCHOOL-PAK School Lunch Sloppy Joe Mix & Textured Vegetable Protein	52.13% or 28-3/4 oz per 3 lb 7 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	NATIONAL SCHOOL-PAK School Lunch Spaghetti Sauce Mix & Textured Vegetable Protein	46.58% or 16-3/4 oz per 2 lb 4 oz pkg. (net wt.)	100 1-ounce equivalent servings of meat/meat alternate per pkg.
	NATIONAL SCHOOL-PAK School Lunch Taco Mix & Textured Vegetable Protein	61.82% or 24-3/4 oz per 2 lb 8 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the NATIONAL SCHOOL-PAK mixes is GL-219, PROMATE #500-SL or PROMATE #100-SL manufactured by Griffith.

North American Laboratory Co., Inc. 1717 W. 10th Street Indianapolis, IN 46206	MENU MAGIC MEAT TWIN or MEAT TWIN V	88.89% or 2 lb per 2 lb 4 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	MENU MAGIC Chili Seasoning	47.33% or 22-3/4 oz per 2 lb 2 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	MENU MAGIC Meat Loaf and Meat Ball Seasoning	62.75% or 2 lb per 3 lb 3 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.

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COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
North American Laboratory Co., Inc. (continued)	MENU MAGIC Pizza Burger Seasoning	63.77% or 26-3/4 oz per 2 lb 10 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	MENU MAGIC Sloppy Joe Seasoning	62.75% or 2 lb per 3 lb 4 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	MENU MAGIC Spaghetti Sauce Seasoning	49.56% or 31-1/2 oz per 4 lb pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	MENU MAGIC Taco Seasoning	80% or 2 lb per 2 lb 8 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the MENU MAGIC mixes is VMR II, uncolored manufactured by Nabisco or TVP, minced 180, fortified, color C manufactured by Archer Daniels Midland.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Nugget Distributors, Inc. P. O. Box 8309 Stockton, CA 95204	NUGGET School Lunch Chili Mix & Textured Vegetable Protein	42.06% or 17-3/4 oz per 2 lb 10 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	NUGGET School Lunch Meat Loaf/Meat Ball Mix & Textured Vegetable Protein	48.93% or 20 oz per 2 lb 9 oz pkg. (net wt.)	84 2-ounce equivalent servings of meat/meat alternate per pkg.
	NUGGET School Lunch Patty Mix & Textured Vegetable Protein	83.03% or 30-1/4 oz per 2 lb 4-1/2 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	NUGGET School Lunch Pizza Sauce Mix & Textured Vegetable Protein	55% or 17-1/2 oz per 2 lb pkg. (net wt.)	112 2-ounce equivalent servings of meat/meat alternate per pkg.
	NUGGET School Lunch Sloppy Joe Mix & Textured Vegetable Protein	52.13% or 28-3/4 oz per 3 lb 7 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	NUGGET School Lunch Spaghetti Sauce Mix & Textured Vegetable Protein	46.58% or 16-3/4 oz per 2 lb 4 oz pkg. (net wt.)	100 1-ounce equivalent servings of meat/meat alternate per pkg.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Nugget Distributors, Inc. (continued)	NUGGET School Lunch Taco Mix & Textured Vegetable Protein	61.82% or 24-3/4 oz per 2 lb 8 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the NUGGET mixes is GL-219, PROMATE #500-SL or PROMATE #100-SL manufactured by Griffith.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Sysco Corporation Capital National Bank Building Suite 800 1300 Main Street Houston, TX 77002	SYSCO School Lunch Chili Mix & Textured Vegetable Protein	42.06% or 17-3/4 oz per 2 lb 10 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	SYSCO School Lunch Meat Loaf/Meat Ball Mix & Textured Vegetable Protein	48.93% or 20 oz per 2 lb 9 oz pkg. (net wt.)	84 2-ounce equivalent servings of meat/meat alternate per pkg.
	SYSCO School Lunch Patty Mix & Textured Vegetable Protein	83.03% or 30-1/4 oz per 2 lb 4-1/2 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	SYSCO School Lunch Pizza Sauce Mix & Textured Vegetable Protein	55% or 17-1/2 oz per 2 lb pkg. (net wt.)	112 2-ounce equivalent servings of meat/meat alternate per pkg.
	SYSCO School Lunch Sloppy Joe Mix & Textured Vegetable Protein	52.13% or 28-3/4 oz per 3 lb 7 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	SYSCO School Lunch Spaghetti Sauce Mix & Textured Vegetable Protein	46.58% or 16-3/4 oz per 2 lb 4 oz pkg. (net wt.)	100 1-ounce equivalent servings of meat/meat alternate per pkg.
	SYSCO School Lunch Taco Mix & Textured Vegetable Protein	61.82% or 24-3/4 oz per 2 lb 8 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.

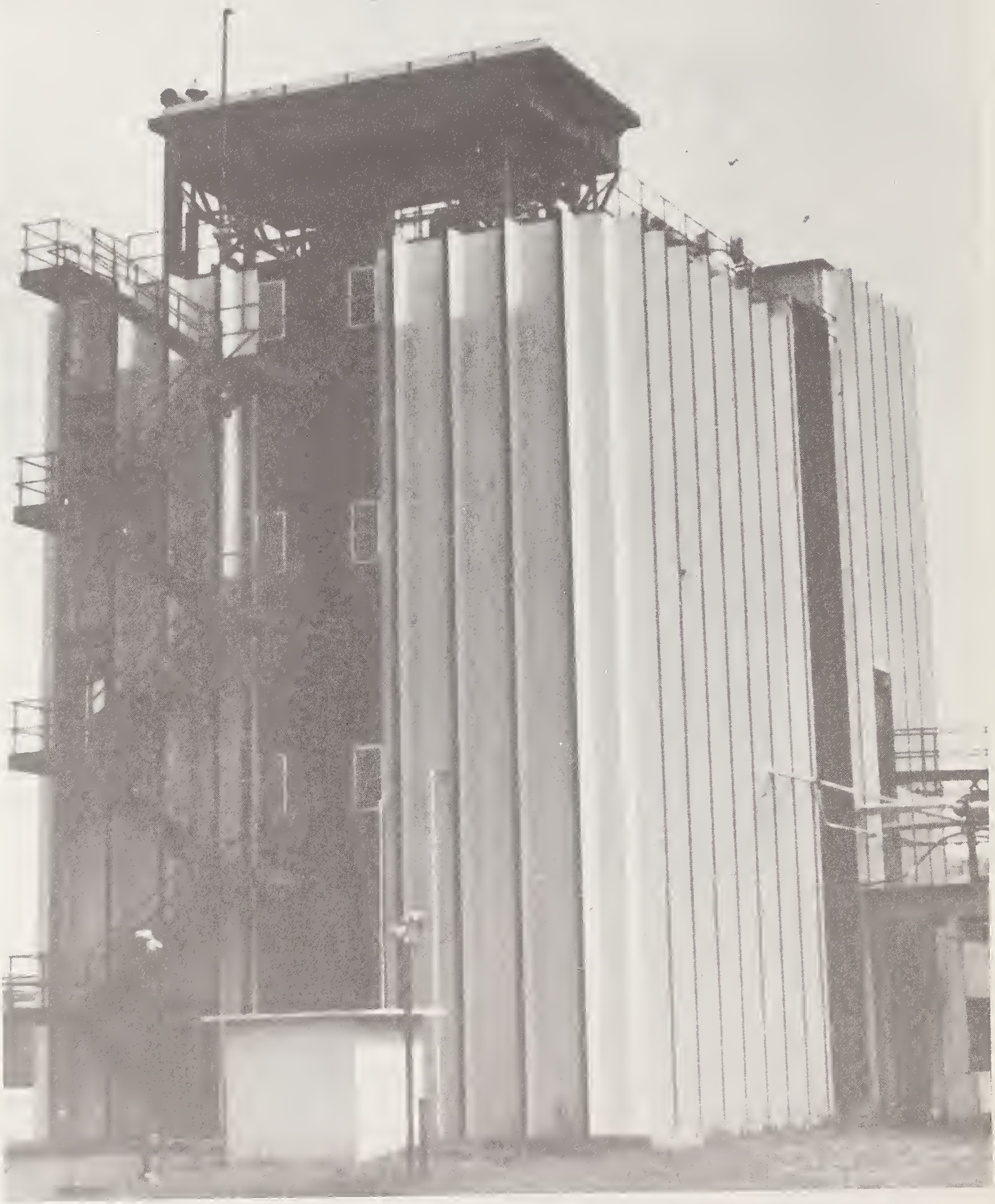
Note: The textured vegetable protein component of the SYSCO mixes is GL-219, PROMATE #500-SL or PROMATE #100-SL manufactured by Griffith.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Williams Foods, Inc. 1900 West 47th Place Westwood, KS 66205	WILLIAMS EXPAND Textured Vegetable Protein with Chili Seasoning	81.25% or 26 oz per 2 lb pkg. (net wt.)	119 2-ounce equivalent servings of meat/meat alternate per pkg.
	WILLIAMS EXPAND Textured Vegetable Protein with Meat Loaf Seasoning	63.41% or 26 oz per 2 lb 9 oz pkg. (net wt.)	80 2-ounce equivalent servings of meat/meat alternate per pkg.
	WILLIAMS EXPAND Textured Vegetable Protein with Patty Seasoning	63.41% or 26 oz per 2 lb 9 oz pkg. (net wt.)	83 2-ounce equivalent servings of meat/meat alternate per pkg.
	WILLIAMS EXPAND Textured Vegetable Protein with Sloppy Joe Seasoning	63.41% or 26 oz per 2 lb 9 oz pkg. (net wt.)	83 2-ounce equivalent servings of meat/meat alternate per pkg.
	WILLIAMS EXPAND Textured Vegetable Protein with Spaghetti Sauce Mix	63.41% or 26 oz per 2 lb 9 oz pkg. (net wt.)	83 2-ounce equivalent servings of meat/meat alternate per pkg.
	WILLIAMS EXPAND Textured Vegetable Protein with Taco Seasoning	63.41% or 26 oz per 2 lb 9 oz pkg. (net wt.)	83 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the WILLIAMS EXPAND mixes is ULTRA-SOY (F) manufactured by Far-Mar-Co or TEXTRATEIN F manufactured by Cargill.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
The Golden Dipt Company Division of DCA Food Industries, Inc. 100 E. Washington Street Millstadt, IL 62260	GOLDEN DIPT/DCA CHILI MATE, Fortified Textured Vegetable Protein with Chili Seasoning	81.25% or 26 oz per 2 lb pkg. (net wt.)	83 2-ounce equivalent servings of meat/meat alternate per pkg.
	GOLDEN DIPT/DCA MEAT LOAF MATE, Fortified Textured Vegetable Protein with Meat Loaf Seasoning	63.41% or 26 oz per 2 lb 9 oz pkg. (net wt.)	80 2-ounce equivalent servings of meat/meat alternate per pkg.
	GOLDEN DIPT/DCA HAMBURGER MATE, Fortified Textured Vegetable Protein with Patty Seasoning	63.41% or 26 oz per 2 lb 9 oz pkg. (net wt.)	83 2-ounce equivalent servings of meat/meat alternate per pkg.
	GOLDEN DIPT/DCA SLOPPY JOE MATE, Fortified Textured Vegetable Protein with Sloppy Joe Seasoning	63.41% or 26 oz per 2 lb 9 oz pkg. (net wt.)	83 2-ounce equivalent servings of meat/meat alternate per pkg.
	GOLDEN DIPT/DCA SPAGHETTI MATE, Fortified Textured Vegetable Protein with Spaghetti Sauce Mix	63.41% or 26 oz per 2 lb 9 oz pkg. (net wt.)	83 2-ounce equivalent servings of meat/meat alternate per pkg.
	GOLDEN DIPT/DCA TACO MATE, Fortified Textured Vegetable Protein with Taco Seasoning	63.41% or 26 oz per 2 lb 9 oz pkg. (net wt.)	83 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The GOLDEN DIPT/DCA mixes are identical to the corresponding mixes manufactured by Williams Foods, Inc.



FAR-MAR-CO edible soy processing plant located in St. Joseph, Missouri.

FARMER COOPERATIVE SERVICE
U.S. DEPARTMENT OF AGRICULTURE

Farmer Cooperative Service provides research, management, and educational assistance to cooperatives to strengthen the economic position of farmers and other rural residents. It works directly with cooperative leaders and Federal and State agencies to improve organization, leadership, and operation of cooperatives and to give guidance to further development.

The Service (1) helps farmers and other rural residents obtain supplies and services at lower cost and to get better prices for products they sell; (2) advises rural residents on developing existing resources through cooperative action to enhance rural living; (3) helps cooperatives improve services and operating efficiency; (4) informs members, directors, employees, and the public on how cooperatives work and benefit their members and their communities; and (5) encourages international cooperative programs.

The Service publishes research and educational materials and issues *News for Farmer Cooperatives*. All programs and activities are conducted on a nondiscriminatory basis, without regard to race, creed, color, sex, or national origin.